AD-A054 897 FACILITY CHECKING SQUADRON (1866TH) (AFCS) SCOTT AFB IL F/G 17/9
RADAR STATION EVALUATION REPORT, WILLIAMS AFB, ARIZONA, 16-25 J--ETC(U)
APR 78 E T PINNERY
UNCLASSIFIED 78/66R-115 NL

1 OF 1

AD
A054897

END
DATE
FILMED
7-78
DDC

FOR FURTHER TRAN

(12)

AD A054897

AIR FORCE COMMUNICATIONS SERVICE

TRACALS EVALUATION REPORT (Final)

(9)

(14) 78/66R-115

(6) RADAR STATION EVALUATION REPORT

Williams AFB, Arizona

78/66R-115

16-25 January 1978

(10) Earl T. Binney

(12) 78 p.

(11) 21 Apr 78

AIR FORCE COMMUNICATIONS SERVICE

DISTRIBUTION STATEMENT A
Approved for public release;
Distribution Unlimited

408 827 mt

DEPARTMENT OF THE AIR FORCE
1866 Facility Checking Squadron (AFCS)
Scott AFB, Illinois 62225

21 April 1978

RADAR STATION EVALUATION REPORT

Williams AFB, Arizona

78/66R-115

16-25 January 1978

Prepared By:

Earl T. Pinney, Jr.
EARL T. PINNEY, JR., Capt, USAF
Radar Evaluation Team Chief

Approved By:

Cecil C. Robins
CECIL C. ROBINS, Major, USAF
Commander

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER 78/66R-115	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) RADAR STATION EVALUATION REPORT Williams AFB, Arizona		5. TYPE OF REPORT & PERIOD COVERED Final 16-25 January 1978
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) EARL T. PINNEY, Jr., Capt, USAF		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS 1866 Facility Checking Squadron (AFCS) Scott AFB, Illinois 62225		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS Hq Air Force Communications Service/FFOT Scott AFB, Illinois 62225		12. REPORT DATE 21 April 1978
		13. NUMBER OF PAGES 80
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)
Approved for public release distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)
Same as report

18. SUPPLEMENTARY NOTES
None

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

TRACALS	IFF/SIF
AN/GPN-12	ASR-7
AN/TPX-42	SSR
ATCRBS	GCA
Radar Evaluation	Williams AFB

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)
This traffic control and landing systems (TRACALS) radar station evaluation report presents data collected from 16-25 January 1978 to define the capabilities and limitations of the ground controlled approach (GCA) facility at Williams AFB, AZ. The GCA is composed of an AN/GPN-12 airport surveillance radar (ASR), AN/TPX-42A (V) Type III air traffic control radar beacon system ATCRBS), AN/FPN-61 precision approach radar (PAR), and the associated power systems. This report includes descriptions of the useable ASR coverage and tracking capabilities, the useable ATCRBS coverage and tracking capabilities, the

BLOCK 20 ABSTRACT.
analysis of flight and equipment performance data, and the performance predictions for the ASR and ATCRBS systems. The data presented can be used as a guide for anticipated equipment performance until there is an addition, or relocation of equipment or until a change occurs in the horizontal profile.

DISTRIBUTION

Number of Copies	Addressee
4	1922 Communications Squadron, Williams AFB, AZ 85224
2	82 FTW, Williams AFB, AZ 85224
2	SCA/EIEL, Oklahoma City AFS, OK 73145
1	SCA/EIPT, Oklahoma City AFS, OK 73145
2	SCA/FF, Oklahoma City AFS, OK 73145
2	SCA/LG, Oklahoma City AFS, 73145
2	PCA/EIP, Hickam AFB, HI 96853
1	PCA/EIS, Hickam AFB, HI 96853
10	1866 FCS/CC, Scott AFB, IL 62225
2	1867 FCS/CC, APO San Francisco 96328
2	1868 FCS/CC, APO New York 09057
1	1844 EES/EIELT, Griffiss AFB, NY 13441
2	1842 EEG/EEIT, Scott AFB, IL 62225
1	1843 EES/EIELT, Hickam AFB, HI 96853
1	HQ AFCS/OA, Scott AFB, IL 62225
1	HQ AFCS/IGP, Scott AFB, IL 62225
2	HQ AFCS/LGMBF, Scott AFB, IL 62225
1	HQ AFCS/DAPL, Scott AFB, IL 62225
1	HQ AFCS/FFC, Scott AFB, IL 62225
1	HQ AFCS/LGMSE, Scott AFB, IL 62225
1	HQ AFCS/FFN, Scott AFB, IL 62225
2	HQ AFCS/FFOT, Scott AFB, IL 62225
12	DDC-TC, Cameron Station, Alexandria, VA 22314
5	FAA/ARD-5, 800 Independence Ave SW, Washington, DC 20590
2	FAA/FSNFO/AFS-503, P.O. Box 25082, Oklahoma City, OK 73125
2	HQ ADCOM/KRLS, Ent AFB, CO 80912
1	Dr. Alexis Shlanta, Code 3173, Naval Weapons Center, China Lake, CA 93555

ACCESSION for
NTIS White Section ☒
DDC Buff Section ☐
UNANNOUNCED ☐
JUSTIFICATION ....

BY..................................
DISTRIBUTION/AVAILABILITY CODES

Dist.	AVAIL. and/or SPECIAL	
A		

TABLE OF CONTENTS

1. SUMMARY

1-1. Airport Surveillance Radar (ASR)

a. Equipment Performance: During the ground phase one moving target indicator (MTI) intermediate frequency (IF) bandwidth and one preamplifier bandwidth were out of specifications. The MTI IF bandwidth was corrected but the preamplifier bandwidth was not (see para 4-2b). The magnetrons used as suitable substitutes in the AN/GPN-12 were unstable. Four different magnetrons were tried before an acceptable one was found. The voltage regulator for the AN/GPN-12 at Williams is unable to provide stable input power to the system and caused severe system instability. The evaluation was completed using unregulated commercial power that was monitored to ensure proper input levels. The indicators had a poor dynamic range that was improved after an indicator alignment was performed.

b. Evaluation Results: The optimum antenna tilt for present operational requirements is 3.75° mechanical, the previously commissioned tilt. This yields an electromagnetic (true) tilt of 3.65°. Maximum outer range tracking capability extended to approximately 25 nautical miles (NM) at 2400 feet mean sea level (MSL), 46 NM at 4400 feet MSL, 47 NM at 6400 feet MSL, 48 NM at 11,400 feet MSL, and 54 NM at 21,400 feet MSL, when tracking a C-140 size aircraft. Linear polarization provided better coverage than circular polarization. Multipath interference (nulling) did cause some holes but generally beyond 20 NM. Screening and MTI tangential blind speeds caused holes in the ASR pattern to runway 30 center. Scan modulation was noted.

c. Capabilities and Limitations: The ASR is capable of performing its assigned Air Traffic Control mission. Nulling affects coverage beyond 20 NM at all altitudes. Nulling and screening should be considered if an expanded mission is required.

1-2. Air Traffic Control Radar Beacon System (ATCRBS)

a. Equipment Performance: Several range and azimuth splits were present when operating on IR-1 (see para 5-2a(1)). The cause of these target splits was not definitely identified during the evaluation. Therefore, the evaluation was continued on IR-2. Difficulty was encountered when aligning the gain time control (GTC) curve but replacement of a video logic 2 card corrected the GTC alignment problem. Excessive line losses were present on the initial check of the OX-16 cabinet. These losses were reduced to acceptable limits by cleaning and tightening several cable connections within the cabinet. The OS-208 Oscilloscope Module of the AN/UPM-137 Test Set was unusable.

b. Evaluation Results: The optimum output power is 200 watts as measured at J5 on the top of the OX-16 cabinet. Coverage consistently extended well beyond the control area at every altitude and extended to 60 NM at 6400 feet MSL and above. No false targets were identified. Nulling did cause holes in the coverage but generally beyond the control area.

c. Capabilities and Limitations: The ATCRBS is capable of performing its assigned Air Traffic Control mission. Nulling affects coverage beyond the present control area and should be considered if an expanded mission is required.

1-3. Power Systems

a. Equipment Performance: Commercial power was being supplied through a backfeeder line because of a blown transformer on the main line. As a result, commercial input power was close to the lower specification limit. This could have contributed to the fluctuations caused by the voltage regulator. The emergency generator did not come on line when the commercial power failed during the evaluation.

b. Adequacy and Reliability: Because of the low line input voltage, the unreliable backup power system, and the voltage regulator problem mentioned in paragraph 1-1, the power systems are considered unreliable.

2. RECOMMENDATIONS

2-1. Airport Surveillance Radar

a. Equipment

(1) All radar maintenance technicians should be briefed on the effects of scan modulation and the degradation of MTI tracking capability caused by reducing MTI processor levels (see para 4-5d).

(2) An engineering investigation should be performed on the voltage regulator to determine if it is capable of providing stable regulated power to the AN/GPN-12 (see para 4-2b).

b. System Configuration: The system configuration outlined in paragraph 4-6 should be used as explained.

c. Coverage: All air traffic controllers should be briefed on the limitations that affect the present operational area; i.e., scan modulation, MTI blind speeds, multipath interference, and screening (see para 4-5).

2-2. Air Traffic Control Radar Beacon System

a. Equipment: The cause of the range and azimuth splits peculiar to IR-1 should be investigated by the local unit.

b. System Configuration: The system configuration outlined in paragraph 5-6 should be used as explained.

c. Coverage: All air traffic controllers should be briefed on the cause of holes in ATCRBS coverage and the important part the aircraft transponder has in proper system operation (see para 5-5).

2-3. Power Systems: The reliability of the commercial power should be improved. The emergency generator should be tested under actual conditions periodically to ensure the automatic changeover feature is operating and that reliable emergency power is available if needed.

3. GENERAL INFORMATION

3-1. Facility Data

a. General

Location: Williams AFB, Arizona
Communication Area: Southern Communications Area
Unit: 1922 Communications Squadron (AFCS)
Commander: Captain John I. Brennecke
Evaluation Period: 16-25 January 1978

b. Airport Surveillance Radar

Equipment: AN/GPN-12
Coordinates: 33° 18' 44.865" N
111° 38' 54.017" W
Ground Elevation at Unit: 1369.6 feet MSL
Elevation at Focal Point: 1393.9 feet MSL
Field Elevation: 1383 feet MSL

c. Air Traffic Control Radar Beacon System

Equipment: AN/TPX-42A (V) Type III
Coordinates: Collocated with ASR
Elevation at Focal Point: 1399.2 feet MSL

3-2. Runway Data

RUNWAY	LENGTH/WIDTH	TRUE AZIMUTH
12C	10,214.46'X150'	134° 32' 48"
30C	10,214.46'X150'	314° 32' 48"

3-3. Mission Area: The Williams Ground Controlled Approach (GCA) is responsible for control of all instrument flight rules (IFR) aircraft operating below 6,000 feet MSL within a 15 NM radius of Williams AFB, AZ. See TAB A for correlation of the Williams GCA operational area with local topography.

3-4. Mission Responsibilities: Williams GCA is responsible for providing vectoring service for IFR aircraft conducting approaches at Williams AFB.

3-5. Primary Using Agency/Aircraft Supported: The primary using agency is the 82 Flying Training Wing. Aircraft normally controlled include the T-37, T-38, and F-5.

3-6. Air Traffic Control (ATC) Facilities: The ATC system consists of a fixed GCA (AN/GPN-12 with AN/TPX-42 and AN/GPA-131), visual flight rules (VFR) control tower (AN/GSA-135 console and overhead mounted BRITE II Radar Indicator), VHF Omni Range/Tactical Air Navigation (VORTAC) and an Instrument Landing System (ILS) to runway 30C.

3-7. Logistic Support: Logistical and precision measurement equipment laboratory support is provided by the host base organizations.

3-8. Key Personnel

a. Ground Evaluation Personnel

Capt E.T. Pinney, Jr. - Team Chief
MSgt D.L. Larson - Air Traffic Control Superintendent
TSgt D. Campos-Lopez - ATC Radar Evaluation Technician
TSgt M.G. Jenner - ATC Radar Evaluation Technician
SSgt R.F. Brunner - ATC Radar Evaluation Technician
SSgt N.D. Culver - Geodetic Surveyor
SSgt D.A. Foor - Air Traffic Control Technician
SSgt J.A. Huehn - ATC Radar Evaluation Technician
SSgt R.F. Innis - ATC Radar Evaluation Technician
SSgt L.O. Nowak - ATC Radar Evaluation Technician

b. Airborne Evaluation Personnel

Capt D.W. Abati - Aircraft Commander
Capt L.R. Duncan - First Pilot
SMSgt A.N. Haus - Flight Inspection Technician
SSgt M.J. Aufieri - Flight Inspection Technician
SSgt L.E. Kiracofe - Flight Mechanic

c. Facility Personnel Contacted

Capt J.I. Brennecke - Commander
Capt J.A. Aston - Chief, Air Traffic Control Operations
1Lt M.E. Stevens - Chief of Maintenance
SMSgt R.I. Baker - Chief Controller, GCA
SMSgt H.R. Gallegos - NCOIC, ATC Operations
MSgt F.A. Bowman - NCOIC, Radar Maintenance
MSgt T.R. Drysdale - Training and Standardization Specialist
MSgt F.D. Lewellen - Chief Controller, Tower

4. AIRPORT SURVEILLANCE RADAR

4-1. System Description

a. General: The ASR system is comprised of an AN/GPN-12 solid state, dual channel, S-band (2700-2900 MHz) radar that employs digital processing; an AN/GPA-131 solid state video mapper; and the OD-58/T solid state indicator group.

(1) AN/GPN-12: The AN/GPN-12 is used to detect and track aircraft within 60 NM of the antenna and provide a corresponding output video signal for display on the plan position indicator (PPI). A six-pulse repetition frequency (PRF) stagger mode of operation is employed for the virtual elimination of blind speeds below Mach 2.

(a) Antenna System: Radar energy is transmitted and received via an ASR-7 antenna system. The beam pattern is fan shaped extending from -3° to 30° in elevation and has an azimuth width of 1.5°. The antenna rotates at 13 $\pm$ 1 revolutions per minute. Linear and circular polarization features are available.

(b) Transmitter System: Each transmitter uses an air-cooled manually tunable magnetron. Transmitter average output power range is 252 watts to 425 watts depending on the selected PRF. Stagger PRF is used for normal operation with the average output power set for 355 watts prior to high voltage regulation.

(c) Receiver System: The receiver system includes a low noise parametric amplifier which provides a minimum radio frequency (RF) signal gain of 15 dB. Subsequent to the preamplifier, the receiver is divided into three signal paths: Normal, MTI, and Logarithmic IF with fast time constant (Log FTC). The MTI channel contains a dual digital canceller with selectable feedback for velocity shaping. Four different velocity response shapes provide an MTI subclutter visibility (SCV) relative to scanning clutter of 25, 30, 35, and 40 dB. Sensitivity time control (STC) and gain controls are placed in the RF section prior to the parametric amplifier to control the received signal level without affecting the receiver noise level. Four selectable modes of STC are provided for control of receiver RF gain. Special filters are built into the RF section to reduce electromagnetic interference.

(d) Processor System

1. The function of the Normal channel is to process the Normal and Log FTC videos to yield the following signals for display: Normal video, enhanced Normal video, Normal Log FTC video, Normal Log FTC video with weather background, enhanced Normal Log FTC video, or enhanced Normal Log FTC video with weather background.

2. The video enhancer is designed to increase the received signal-to-noise ratio and eliminate nonsynchronous interference.

3. The Log FTC circuits are designed to eliminate weather clutter and provide the capability of detecting large targets in the clutter which would normally be lost due to receiver saturation.

4. Weather background circuits provide a background weather signal for display when the Log FTC function is selected. This background signal will aid the radar controller in directing aircraft around intense weather areas.

5. The MTI channel eliminates fixed target returns and processes moving target returns for display. The MTI video can then be further processed by a Log FTC circuit, an enhancer circuit, or a weather background circuit to produce the following selectable types of video: MTI video, enhanced MTI video, MTI Log FTC video, MTI Log FTC video with weather background, enhanced MTI Log FTC video, or enhanced MTI Log FTC video with weather background. The operation of the Log FTC, enhancer, and weather background circuits in the MTI channel are the same as in the Normal channel.

(2) OD-58/T Indicator System: The PPI group OD-58/T provides synthetic target writing capabilities. The indicator group contains a 22 inch diameter cathode ray tube (CRT) which provides a display of range and azimuth of primary radar returns and ATCRBS information. The variable MTI range gate allows the controller to select the range of the MTI video. Functions are included for map video and auxiliary radar video display. Fixed and variable sweep ranges from 7.5 to 240 NM can be selected with range mark intervals of 2, 5, 10, and 40 NM depending on the range selected.

(3) AN/GPA-131 Video Mapping Group: The video mapper is a solid state device which provides air traffic controllers references to previously established geographic and/or navigational points. It uses a flying spot scanner (rotating sweep on a CRT) to provide a synchronous (with radar antenna) light source through a film transparency containing map information. A photomultiplier tube converts this data to a video signal for display on the PPI. The mapper contains five map channels, each with its own flying spot scanner, and a replacement map slide. One or more video maps may be selected for simultaneous display on the PPI. The video mapper has the capability to support a maximum of twelve indicators. The map video is range gated to be coincident with the radar video. Thus, different ranges may be used or expanded, and off-centering of any given channel may be employed without altering the geometric correlation of map and radar data.

b. Special: The ASR at Williams AFB operates at a transmitter frequency of 2800 MHz.

c. Facility Equipment

(1) Radar Set: AN/GPN-12, SN 39

(2) Antenna Type: ASR-7, SN 3051

(3) Video Mapper: AN/GPA-131, SN 79

4-2. Equipment Status: Equipment checks were performed in accordance with existing technical orders and current evaluation procedures. Results of these checks are presented in TABs E-1-1/8. Pre and post flight equipment checks were conducted to ensure the radar equipment was stable and within minimum operating standards during the flight phase (see TAB E-4-1). Due to major subcomponent outages on channel B, equipment checks were performed only on channel A. Results of the ASR subsystem checks are stated below.

a. Antenna System

(1) Feedhorn alignment checks indicated all cross hairs were within the alignment tolerance circles. There are no angle, elevation and focus (AEF) measurements (see TAB E-1-9) available from Texas Instruments, Inc. for the AN/GPN-12. Therefore, no comparison is possible between factory specifications and actual findings as listed in TAB E-1-1. These AEF measurements should be used in conjunction with the alignment telescope for future feedhorn alignment verification.

(2) Solar data indicated the electromagnetic tilt to be 0.10° below the indicated mechanical tilt of the antenna assembly. Solar data also revealed a 4.5° deviation on the antenna azimuth ring orientation. This should be corrected by rotating the ASR antenna azimuth ring 4.5° counterclockwise (see TABs E-1-6/7).

(3) Unless otherwise indicated, all references to antenna tilt throughout this report refer to the indicated mechanical tilt of the antenna system.

b. Channel A: The parametric amplifier gain was adjusted to technical order specifications. The bandwidth check revealed a MTI IF amplifier out of specification. This component was replaced out of local supply point levels. An attempt to correct an out-of-tolerance preamplifier bandwidth was made by swapping another preamplifier into the receiver system. This exchange did not correct the bandwidth problem and since the system MDS and noise figure were acceptable, the condition was left as found and should have had no adverse effect on evaluation results. Commercial power fluctuations apparently caused the failure of two coho amplifier modules. This component had to be replaced after

procurement from Luke AFB. From the beginning of the evaluation, system stability was hampered by apparent jittery automatic frequency control (AFC) operation. The continued checks into system instability also revealed considerable fluctuations on the high voltage power supply voltage and current, modulator driver current, and line voltage regulator output. Further investigation of the unstable situation revealed other abnormalities in addition to the commercial power problems mentioned in Chapter 7. First, when shutting either the transmitter or the antenna drive motor off, the meter fluctuations were completely eliminated. Second, when the voltage regulator was bypassed, and the system was operated on unregulated commercial power, the fluctuations also were eliminated. Therefore, it is concluded that the voltage regulator is not capable of supplying stable regulated power to the AN/GPN-12 at Williams AFB. An engineering investigation into this problem should be conducted. The evaluation was continued on unregulated commercial power. However, there was still substantial jitter on the magnetron current pulse which caused unstable MTI operation. The piece of waveguide containing the ferrite circulator was removed to check for anything causing magnetron loading. Two small pieces of rubber gasket were found and removed from inside of the waveguide. The inside of the waveguide also looked dull and dirty and was vacuumed clean. Exchange of four different magnetrons finally resulted in the magnetron stability necessary for good MTI operation. Velocity response shaping (VRS) modes on channel A were inoperative.

c. Channel B: Problems with the parametric amplifier and AFC module precluded the completion of channel B equipment checks. Therefore, channel B check results do not appear in this report.

d. Indicators: All indicators in the GCA appeared to be aligned below their video capabilities. Indicator number 1 was realigned and the signal to noise ratio was improved which provided an increased dynamic range of the indicator. The dynamic range is the signal level ratio between target strength just at "bloom" level and minimum discernable target strength on the PPI.

e. Video mapper: The video mapper was checked using current evaluation procedures (see TAB E-1-5). Video mapper equipment performance was satisfactory. However, since permanent echo alignment "Vs" were not on the map, proper correlation of the map to the permanent echos was not possible. The "T" alignment alone is not sufficient to ensure an accurate presentation. Therefore, the map should be corrected.

4-3. <u>Environmental Factors</u>

a. Siting Characteristics: The ASR site is located in the northeast corner of the base, approximately 1350 feet northeast of the three parallel runways, with the tower and GCA facility on the opposite side of the runways. The immediate area around the ASR antenna consists

of flat and typical desert terrain. This flat terrain and the proximity of three active runways, several associated taxiways and extensive areas of paved aircraft parking facilities are highly susceptible to multipath interference effects on radar coverage. The radar site is also surrounded by mountain ranges of considerable elevation all the way from the northeast to the southeast within a 15 to 30 NM radius. These surrounding mountains will cause line of sight screening limitations and could cause tracking losses due to subclutter visibility limitations of the MTI system. TAB B-1/4 depicts screening angles and panoramic photographs taken at the antenna and TAB C-1 depicts line of sight coverage at various altitudes.

b. Weather

(1) Surface Climatology: Williams AFB has a mean daily maximum temperature of 103° Fahrenheit in July and a mean daily minimum temperature of 38° Fahrenheit in December and January. The average annual precipitation is seven inches.

(2) Propagation Climatology

(a) Winter: During the winter, Williams AFB is influenced by cold moist air from the North Pacific. This air mass has been considerably modified as it traveled over the mountains, resulting in dry warm conditions in the low levels. These conditions contribute to standard or slightly subrefractive propagation. Occasionally, a strong high pressure system moves in over Williams. It is characterized by a strong subsidence inversion aloft. This inversion will tend to weaken or destory subrefractive layers and intensify superrefractive layers.

(b) Summer: During the summer, the "heat low" is the predominant weather feature, bringing in warm moist southerly air at the surface. This air may be overrun by warm dry air from the north. A superrefractive layer will be created at the zone of mixing due to the moisture decrease and temperature increase vertically through the layer. Occasionally, radiational cooling on clear calm nights may establish an inversion layer and, when accompanied by a decrease in moisture, will lead to superrefractive and possible trapping conditions.

(c) Spring and Fall: Spring and Fall seasons serve as transitional periods between the maximum superrefractive activity of summer and more normal propagation conditions in winter.

(d) Refractive Conditions: The chart "Frequency of Refractive Conditions in Percent" (see TAB G-2) is derived from summaries of atmospheric refractive index prepared by the USAF Environmental Technical Applications Center (AWS). It was computed for the nearest rawinsonde station considered to be representative of this site. The chart represents a count by month, over the period of record of three or more years, of the minimum gradient category in percent frequency of

occurrence. Only the one minimum gradient category in each upper air sounding has been counted. For this reason subrefraction is seldom shown on the chart, as more negative gradients will usually be found and counted. A discussion of refractive theory and a description of the refractive index categories and their corresponding gradients in N-units per 1000 feet is found in TABs G-1-1/2 and G-2.

(3) Evaluation Weather Conditions: Upper air propagation analyses were obtained from Tucson, the nearest rawinsonde site considered to be representative of the refractive conditions present at Williams AFB during the evaluation. These analyses revealed the presence of normal refractive conditions throughout the evaluation. Therefore, weather probably had negligible effect on radar coverage during the flight phase.

c. Electromagnetic Environment: No electromagnetic interference (EMI) was encountered during the evaluation.

4-4. Evaluation Profile: The overall objective of this evaluation was to determine the capabilities and limitations and to optimize this AN/GPN-12 in its installed environment at Williams AFB. The only way to measure its performance is to track a known target and compare the results to both theoretical predictions and previous data from similar radars. However, before tracking this known target, the equipment must be ruled out as a cause of any performance degradation that would effect the evaluation data. Therefore, the evaluation consisted of two phases, a ground phase and a flight phase. Specific objectives and methods followed to meet those objectives are explained in the following paragraphs.

a. Ground Phase

(1) To ensure equipment performance had no adverse effect on the evaluation results, extensive equipment checks were performed to verify that system parameters met technical order specifications.

(2) To document the environmental effects on ASR coverage, an airfield survey and horizontal screening survey were performed and data on terrain features, EMI and weather conditions were collected.

(3) To determine the electromagnetic (true) antenna tilt and azimuth ring alignment using the solar method, known positions of the sun were compared with receiver voltage peaks as the antenna was manually turned across the sun's position. The highest voltage peaks indicate that the sun is traversing the main lobe of the antenna beam pattern. This point is the electromagnetic or true tilt of the antenna. Comparing the true tilt with the mechanical tilt reading results in the tilt error. At the same time, azimuth readings on the bullring were taken at the voltage peaks for comparison with the known sun positions.

(4) To document the clutter environment at various ASR antenna tilts and to determine which tilts to evaluate during the flight phase, the indicator presentation was photographed with various amounts of RF attenuation inserted at the parametric amplifier, and a detailed analysis of the results was performed.

(5) To ensure proper equipment performance during the flight phase, pre and post flight equipment checks were performed.

b. Flight Phase: The second phase consisted of sorties flown by a USAF C-140 flight inspection aircraft to evaluate radar performance. The flight phase objectives are stated below.

(1) To determine the optimum tilt, the aircraft was flown at 6400 feet MSL on the 230 radial from the Chandler VORTAC. The maximum/minimum range and tracking quality of each antenna tilt was measured. The optimum tilt was then determined by compromising between clutter intensity, maximum/minimum range capabilities, severity of lobing holes, and tracking quality as measured by average target strength (ATS) and blip scan ratio (BSR) (See TAB F-1-1), while still meeting operational requirements.

(2) To establish the optimum antenna tilt if it differed from the commissioned tilt, a flight inspection in accordance with AFM 55-8 would be performed.

(3) To document the vertical profile of the antenna beam pattern, the aircraft was flown at selected altitudes along the 230 radial from the Chandler VORTAC.

(4) To confirm the extent of MTI blind speed notches and to document the effect of stagger PRF on these notches, the aircraft was flown at 6400 feet MSL out the 022 radial of the Casa Grande VORTAC at a ground speed of 250 knots.

(5) To document the effects of the ASR special features, the aircraft was flown at 6400 feet MSL on the 230 radial of the Chandler VORTAC with selected ASR feature configurations.

(6) To document the coverage of the ASR approaches, the approaches to runway 13 center and 31 center were flown.

c. Equipment Configuration: Unless otherwise noted, all flight data were collected with the following ASR configuration: Circular polarization (CP), stagger PRF on, MTI gated to 35 NM, STC-1 selected, and receiver gain at maximum.

4-5. Analysis of Evaluation Results

a. Equipment Performance: All equipment operated satisfactorily throughout the flight phase, except as stated in paragraph 4-2, and thus was ruled out as a cause of degradation in radar coverage.

b. Optimum Tilt Determination

(1) Clutter intensity photographs were taken for antenna tilts of 4.0°, 3.75°, 3.5°, and 3.25° (see TABs D-1-1 and D-2-1/4). These photographs indicate that clutter intensity does not appreciably increase as the tilt is lowered from 4.0° to 3.25°.

(2) In addition to clutter intensity studies, annular subclutter visibility photographs were taken as a relative measure of

MTI system operation. A signal pulse approximately equal to a return signal from a C-140 size aircraft is injected into the system at selected ranges. As clutter strength increases, the clutter to signal power ratio increases. If the clutter is strong enough, this ratio becomes larger than the subclutter visibility (SCV) of the MTI receiver and the target is not visible on the indicator. As can be seen in TAB D-1-2, the injected pulse was lost at several locations. However, the size of these holes did not appreciably increase as the tilt was lowered. Therefore, the 4.0°, 3.75°, and the 3.25° tilts were evaluated during the flight phase.

(3) Table 4-1 summarizes the tilt determination flight results (see TABs F-1-1/3 and F-2) and shows the following:

(a) All three tilts satisfy the operational requirements (6000 feet, 15 NM) at Williams AFB.

(b) The maximum useable outer range is greatest at 3.25°, but is only about 3 NM greater than the 3.75° tilt at 6400 feet MSL.

(c) The ATS and BSR are essentially equal within the MTI gated area of 35 NM for all three tilts.

TABLE 4-1
TILT DETERMINATION TRACKING DATA

TILT	AVERAGE MAXIMUM RANGE (NM)	AVERAGE ATS MTI	OVERALL	AVERAGE BSR MTI	OVERALL
4.0°	45.3	2.61	2.40	86	79
3.75°*	46.8	2.51	2.20	82	70
3.25°	50.0	2.61	2.19	86	72

*Average of all tracks flown in CP at 6400 feet MSL.

(4) The commissioned 3.75° tilt is considered optimum for the present needs. If the operational requirements are increased, and outer range tracking capability needs to be increased, the lower 3.25° tilt may be commissioned and will increase coverage comparable to that shown in Table 4-1.

c. Vertical Profile: TABs F-1-3 and F-3 contain the measured vertical profile and are representative of the coverage capabilities of the ASR system. These capabilities are limited as discussed below.

(1) Evaluation of the inner fringe tracking capability indicates it is limited by the normal cone of silence characteristic of all ASR radars.

(2) Outer range tracking capability closely paralleled that predicted for a C-140 size aircraft. Maximum useable outer range tracking capability for a C-140 size aircraft extended to 25 NM at 2400 feet MSL, approximately 12 NM (7 dB) shorter than predicted. At 4400 feet MSL, coverage extended to 46 NM, approximately 4 NM (1.5 dB) longer than predicted. At 6400 feet MSL, coverage extended to approximately 47 NM, fairly close to the prediction. At 11,400 feet MSL, coverage extended to approximately 48 NM, 6 NM (2 dB) shorter than predicted. At 21,400 feet MSL, coverage extended to approximately 54 NM, 6 NM (2 dB) shorter than predicted. These outer ranges and the tracking quality within these ranges were affected by multipath interference as discussed below.

(3) Holes in radar coverage, or loss of targets for three or more consecutive scans, are generally caused by clutter saturation of the receiver, MTI blind speeds, SCV limitations of the MTI receiver, aircraft attitude changes, weather (see TAB G-1-1/2), or multipath interference. To determine the cause of holes depicted in TAB F-3 each of the above possibilities was considered.

(a) Stagger PRF was used to virtually eliminate MTI blind speeds effects within the MTI gated area of 35 NM.

(b) Since the MTI was gated to 35 NM and clutter was not present where the holes occurred, clutter saturation of the receiver and SCV are ruled out as causes of the holes. For further information on SCV and clutter saturation, refer to Traffic Control and Landing System (TRACALS) Special Evaluation Report 75/68R-14, "The Effects of Aircraft Velocity on MTI Systems".

(c) The aircraft radar cross-section varies as the aircraft attitude changes. This variation is unpredictable and could cause random loss of radar targets anywhere in the radar coverage area.

(d) Multipath interference, or nulling, is caused by radar energy reflecting off of the earth's surface and bouncing upward. This reflected energy combines with the direct energy at the target and either weakens (reflected wave is out of phase with the direct wave) the return signal, or strengthens (reflected wave is in phase with the direct wave) the return signal. As a result, angles of minimum power, called null angles, and angles of maximum power, called lobe angles, appear in the vertical coverage pattern. The predicted null locations as calculated in the Federal Aviation Administration Terminal Radar Siting Handbook are compared to the actual hole locations in Table 4-2. Predicted null angles are shown in TAB C-3-1/2.

TABLE 4-2
NULLING ANALYSIS (230 RADIAL)

Altitude (feet AGL)	Null Location (NM) Theoretical	Actual
3000	21.0	Hole 22-23
	26.0	Weak 26-29
		Hole 29-32
	33.0	Hole 35-40
	44.5	Hole 44-*
5000	24.0	Weak 23-24
	28.0	Hole 26-27
	33.0	Hole 33-36
	39.0	Hole 39-45
	48.0	Hole 48-*

*Ranges beyond maximum useable outer range (See TAB F-1-1).

As can be seen, the predicted holes correlate closely to the actual measured holes and weak areas. Therefore, nulling is concluded to be the primary cause of holes throughout the ASR vertical profile. However, this is most prevalent beyond 20 NM and thus should not greatly affect coverage within the operational area at Williams.

d. Moving Target Indicator

(1) An inherent limitation of phase detected MTI systems is the MTI blind speed. The MTI system will cancel aircraft target returns that have an apparent, or radial velocity, to the antenna that is equal or close ($\pm$ 10 knots) to the system blind speed or any whole multiple thereof. Targets are also cancelled when the aircraft is flying an orbit or tangential to the antenna because the MTI system sees these targets as having zero velocity. Tangential is the point where an aircraft ground track is perpendicular to the antenna. The first computed blind speed notch (using AFM 55-8, para 215.3205) for the AN/GPN-12 is centered at 125 knots when the 1200 pulses per second PRF is selected. A system feature that effectively eliminates the blind speed notches, except the tangential notch, is PRF stagger. Comparative results of MTI operation with PRF stagger off and on are shown in TABs F-5-1/2. In TAB F-5-1 note the loss of targets at the first blind speed notch (125 knots) on the 100° and 160° radials and the tangential misses on the 130° radial. In TAB F-5-2, with PRF stagger on, and the canceller mode in cascade, insignificant degradation occurs at the tangential and negligible degradation occurs at the first blind speed notch. This is as expected, since PRF stagger does not eliminate the tangential blind speed notch. PRF stagger should be used to improve the tracking quality of the MTI system. It should be emphasized that MTI tangential blind speeds can occur anywhere within the MTI gated area when the aircraft is flying perpendicular to the antenna. At Williams, tangential blind speeds did cause a loss of radar targets on the downwind and base legs of the ASR approach. All air traffic controllers should be briefed on this limitation.

(2) A second limitation of MTI operation is caused by antenna scan modulation, which appears on the indicator as clutter feedthrough within the MTI gated area. The surfaces of the clutter area are normally rough and jagged and cause the radar returns from the clutter to appear as moving targets to the MTI receiver. Attempts to cancel or remove this clutter feedthrough by methods other than VRS modes (see para 4-5d(5)), selectable on the AN/GPN-12 processor, can greatly degrade MTI performance. Simultaneously reducing MTI processor levels and increasing MTI IF gain for a normal "grass" level on the indicator is the common attempt at reducing clutter feedthrough. This causes weak and washed out MTI video and "blackhole" over the clutter areas within MTI. Blackhole (over cancellation) is an undesirable condition in MTI radar and appears as a loss of "grass," or background residue over the clutter areas. It is caused by excessive IF gain and increases the size of radar holes already present because of other MTI system limitations. It should be noted that scan modulation (i.e. clutter feedthrough) is a normal occurrence and is usually not severe enough to require the use of the VRS modes.

(3) A third limitation to MTI tracking capability is the system subclutter visibility. As mentioned in paragraph 4-5b(2), TAB D-1-2 shows the predicted areas where a C-140 size aircraft return would be lost or extremely degraded. Small aircraft such as the T-37 and T-38 would experience larger radar holes due to SCV limitations.

(4) A final limitation to MTI tracking quality is angel clutter and is usually observed during late evening or sunrise hours. Angel clutter, commonly referred to as anomalous propagation, can be caused by temperature inversion layers and numerous other phenomenon, and is represented on the indicator as numerous clutter "dots" which, when viewed closely, appear to be random slow moving targets. The extent of angel clutter will vary by season throughout the year. When it is extreme enough to limit MTI tracking capability, a VRS mode should be selected. If it is still prevalent and severe enough to affect the safety of air traffic control, radar operations should be suspended and conventional approach control procedures initiated.

(5) Some of the above limitations may be reduced by using one of the four VRS modes. These modes give the MTI system various responses to slow moving targets. The 40 dB mode eliminates faster moving targets than the 25 dB mode. Since scan modulation and angel clutter appear as slow moving targets, use of VRS may reduce these limitations. In addition, VRS may reduce clutter caused by tree movement due to the wind and slow moving automobile traffic. When the VRS modes were selected during the flight phase, scan modulation was increased considerably. Therefore, the data collected was considered invalid. However, when properly operating, this feature can aid in reducing some MTI system limitations and should be used as necessary. The only adverse effect on coverage is a slight widening of the tangential blind speed notch.

e. Horizontal Coverage

(1) The vertical profile analyzed in the previous paragraphs can be expanded to define the total horizontal coverage capability of the ASR by using the environmental data collected during the ground phase. TAB C-1 shows that the coverage is limited at the minimum vectoring altitudes (MVA) due to screening primarily caused by mountains and high terrain. The screening on the 108° radial causes a hole during the right base leg of the ASR approach to runway 30C. This hole can become significant if a MTI tangential blindspeed occurs in conjunction with this screened area (see para 4-5d(1)). TAB F-3 shows the measured maximum outer ranges throughout the vertical profile of the system. These ranges combined with the screening limitations indicate maximum tracking capabilities of the ASR (see TAB C-1).

(2) Another important measure of horizontal coverage capability is the "adequate and reliable" coverage range. According to AFM 55-8, within this range, only isolated or nonrecurring misses (not to exceed misses on three or more consecutive scans) occur. Within the maximum useable outer ranges mentioned above, adequate and reliable coverage extends to approximately 15 NM at 2400, 3000, and 4400 feet MSL, 18 NM at 6400 feet MSL and 25 NM at 11,400 feet MSL. These ranges are accurate for a C-140 size aircraft. Smaller aircraft could have shorter adequate and reliable coverage ranges.

f. Feature Comparison

(1) Video Enhancer

(a) The video enhancer feature increases the overall strength of a target, thereby allowing faint targets to be displayed with more brillance. The effectiveness of the video enhancer was determined using a series of outer fringe checks (see TABs F-1-4 and F-4). The average outer range with the Normal enhancer is 59 NM at 6400 feet MSL. Additionally, the Normal enhancer greatly improved the tracking quality throughout the track. The MTI enhancer improved the outer range to 50 NM compared to 43.5 NM without the enhancer. As with the Normal enhancer, tracking quality throughout the track was greatly improved. These tracks are indicative of the improvement in coverage possible when using the video enhancer.

(b) Generally, air traffic controllers are hesitant to use the video enhancer due to the stretching of the displayed target This, in effect, would shift the displayed center of the target. Since a Federal Aviation Administration (FAA) regulation (Ref: FAAH 7110.65, paragraph 321a) calls for control using the center of the primary target, an inherent error results when using enhanced video. Under worst case conditions, the target can be stretched 31 PRT periods resulting in a maximum center of target error of 1.2°. The center of target displacement for worst case conditions would be 63 feet at 0.5 NM, 1615 feet at 20 NM, and almost 4800 feet at 60 NM (see TABs C-2-1/2). However, when the enhancer is in use, all aircraft targets will incur similar displacements.

(c) Since the Williams AFB operational requirements are fully met without the enhancer, and the primary use of the ASR is for ASR approaches and monitoring other instrument approaches, the stretching effect of the enhancer would adversely affect control of aircraft without any noticeable coverage improvement. Therefore, it is not recommended for normal use but can be used as necessary to increase the strength of weak targets. If an increase of operational requirements is planned, the use of the enhancer can then be judged to determine if it is needed for adequate coverage.

(2) Polarization

(a) Circular polarization reduces clutter from rain, sleet, or snow, and thus increases the controller's ability to track aircraft through these weather conditions while linear polarization (LP) is intended for clear weather.

(b) Data gathered to compare the tracking quality and outer range capabilities of CP and LP show the maximum outer ranges to be approximately equal (see Table 4-3). However, the LP average target strength and blip scan ratio are better. This is as expected since LP should provide better tracking quality.

TABLE 4-3
CP/LP COMPARISONS

MAXIMUM OUTER RANGE		AVG ATS (35-50 NM)	AVG BSR (35-50 NM)
LP	45.5	1.83	59
CP	46.8	1.26	41

During the evaluation, CP tracking capability was measured in clear weather. During adverse weather conditions, such as heavy rain or thunderstorms, the maximum outer range and tracking quality may decrease because of additional rain attenuation.

(3) Sensitivity Time Control: Sensitivity time control will prevent large targets at close range from saturating the receiver (blooming effect) and also allow for full gain presentation of distant targets. In the AN/GPN-12, one of four selectable STC modes is always in use. The rate of attenuation change is adjusted differently for each mode. (see TAB E-1-3) to counteract changes in aircraft size or a failure of the MTI function. The entire flight evaluation was performed with the STC-1 mode selected. No adverse effects were observed.

(4) Logarithmic IF with Fast Time Constant

(a) The Log FTC feature is designed to eliminate weather returns and EMI. When the weather background feature is used in conjunction with the Log FTC circuit, they will eliminate the center portion of the weather returns and display an outline of the weather.

No EMI was observed at Williams AFB, however, the Log FTC circuit has been effective at other AN/GPN-12 locations in reducing certain types of EMI.

(b) The Log FTC feature was evaluated on several tracks to compare its maximum outer range and tracking quality to the configuration used for the vertical profile (See TAB F-4). As expected, the maximum outer range was less than the Normal or MTI tracks. Also, TABs F-1-4 and F-4 show that tracking quality when using Log FTC was slightly reduced. Therefore, when Log FTC is needed to decrease weather or EMI returns, tracking quality and maximum outer range tracking capability will decrease slightly.

4-6. Configuration Selection

a. Tilt: The optimum ASR antenna tilt for the present operational requirements is 3.75° (see para 4-5b).

b. MTI: A 35 NM MTI gate sufficiently eliminates ground clutter returns and provides an adequate, clear radar vectoring area.

c. Stagger PRF: Stagger PRF should be used for day-to-day operation. If clutter feedthrough is present, the lowest SCV mode necessary to effectively reduce the feedthrough should be selected (see para 4-5d). If the feedthrough is not reduced, select the STC setting as in paragraph 4-6g.

d. Polarization: LP should be used for normal operations. CP should be used at the discretion of the controller. During adverse weather conditions, the tracking capability of CP will decrease because of rain and atmospheric moisture attenuation (see para 4-5f(2)).

e. Video Enhancer: The Normal or MTI enhancer should not be used for present normal operations. It can be used to increase the strength of weak returns if necessary for the safe control of aircraft. However, the controller should be aware that the center of the radar target is not the actual location of the aircraft (see para 4-5f(1)).

f. Log FTC: If weather conditions cause excessive clutter on the indicator and CP does not effectively reduce this clutter, Log FTC with weather backgound should be used. Air traffic controllers should be aware of the resultant decrease in tracking quality. (see para 4-5f(4)).

g. STC: STC-1 should be used for normal operation. If inner fringe clutter feedthrough occurs, the lowest STC setting necessary to effectively reduce this occurrence should be used after the highest VRS mode is selected. If target blooming occurs, the lowest STC setting necessary to effectively reduce it should be used (see para 4-5f(3)).

4-7. Capabilities and Limitations: The Williams ASR is capable of performing its assigned Air Traffic Control mission. Radar quality and reliability within the GCA's vectoring airspace (15 NM radius) were considered excellent. Within this area, loses could occur during the turns from downwind to base leg to runway 30. These losses are caused by MTI tangential blind speed loss (see para 4-5d(1)) and screening, (see TAB C-1). They are not considered severe and do not operationally limit the GCA facility at Williams. Generally, adequate and reliable coverage extends to approximately 15 NM at 2400, 3000, and 4400 feet MSL, 18 NM at 6400 feet MSL and 25 NM at 11,400 feet MSL. These ranges and altitudes are accurate for a C-140 size aircraft. Smaller aircraft could have slightly shorter ranges. Should an expanded mission for Williams AFB be contemplated, the increased effects of screening and nulling should be considered (see para 4-5c and 4-5e).

5. AIR TRAFFIC CONTROL RADAR BEACON SYSTEM (ATCRBS)

5-1. System Description

a. General: The AN/TPX-42A interrogator uses digital techniques to provide numeric and symbolic displays of aircraft position, identity, altitude, emergency, communications failure and hijack. The equipment is divided into four major sections: antenna system, interrogator group, signal processing group and indicator control group.

(1) Antenna System: A directional antenna is used to transmit coded interrogation pulses. An omnidirectional antenna radiates a pulse for side lobe suppression. Circuitry within the aircraft transponder compares the level of the pulses and determines if the interrogation is being received from the main lobe (requiring a reply) or from a side lobe (requiring silence). The reply signal on a frequency of 1090 MHz is received by the directional antenna.

(2) Interrogator Group: The coder-synchronizer generates interrogation pulses for modes 1, 2, 3/A and C. Any two numerical modes can be interlaced with mode C with a priority system of 3/A, 2, and 1. The interconnection group houses the interrogator-receiver (IR) units which transmit interrogation pulses at a frequency of 1030 MHz. The transmitter is capable of producing 2000 watts output power in the high power mode, but is normally operated in the low power mode at a maximum power of 300 watts at J5 of the OX-16. The acceptable minimum sensitivity is -86 dBm at TP-1 on the Video Processor Card. Monitoring circuits indicate malfunctions in the receiver and transmitter section. The interference blanker compares beacon video received on a given radar sweep with that received on a previous sweep and removes asynchronous replies. These replies, if not removed, will interfere with normal ground decoding and result in annoying clutter on the displays. Interrogator set control (C-8636/T) performs selection of high or low transmitter power output, corrects for local barometer readings, and selects system operating ranges. It also activates the interference blanker and provides alarm and monitoring functions.

(3) Signal Processing Group: The signal processor compensates for line loss and phase shift, isolates video signals from mode trigger signals and generates mode sensitive triggers which are used to identify modes of interrogations. The video signal processor (VSP) processes valid beacon target information consisting of range, azimuth, altitude, and identity code. This information is in the form of a digital message. The indicator data processor (IDP) processes and stores data in preparation for delivery to the display indicators.

(4) Indicator Control Group: The indicator displays data received from the IDP. Replies from aircraft can be displayed in the form of synthetic video symbols. These symbols indicate an aircraft's position, numeric identity code, altitude and other special information. Bracket video, extracted from aircraft replies, is also displayed on the indicator. The indicator control (C-8625/T) permits the selection of various operating configurations. These include the interrogation

mode, a discrete code identification feature, and the ability to filter aircraft according to altitudes. The aircraft numerical data can be positioned north, south, east, or west, or centered on the target position symbol by using the format position switch.

b. Facility Equipment

(1) Interrogator Set: AN/TPX-42A (V) Type III, SN 073
(2) Directional Antenna: AT-309C/GPX
(3) Omnidirectional Antenna: AT-914
(4) Transponder Test Set: AN/TPX-49
(5) Indicator Group: OD-58 Configuration

5-2. Equipment Status

a. Facility Equipment Status: During the ground phase, the AN/TPX-42 equipment was thoroughly checked using appropriate technical publications and current evaluation procedures. The results of these checks are presented in TABs E-2-1/3. Pre and post flight checks indicated no deviation of performance during the flight evaluation phase (see TAB E-4-2). The overall performance of the ATCRBS indicates a well maintained system, however, areas of concern were encountered as follows:

(1) Several range and azimuth splits were present when operating on IR-1. A range split is a recurrent condition where the same beacon reply symbol appears to be at slightly different ranges on the same azimuth in the same scan period. Azimuth split is a similar condition but in the azimuth plane. An unstable beacon trigger from the synchronizer that is more noticeable when operating in the staggered mode, could have contributed to these splits. However, the evaluation team was unable to pinpoint the exact cause. The local unit should continue to investigate this problem to more accurately identify why the target splits are peculiar to IR-1. The remainder of the evaluation was completed using IR-2.

(2) Difficulty was encountered when aligning the GTC curve. IR-1 video logic 2 card could not be adjusted to obtain 40 dB of attenuation. Replacement of the video logic 2 card alleviated this problem and the GTC was aligned with a curve as indicated in TAB E-2-2.

(3) Excessive line losses were noted between J4 on the back of the IR unit and J5 on top of the OX-16 cabinet. Losses through the cabinet were 4.9 dB for IR-1 and 4.5 dB for IR-2. These figures were subsequently lowered to 3.0 dB and 2.5 dB respectively by cleaning and tightening of RF cable connections within the OX-16 cabinet.

b. Support Test Equipment: The OS-208 Oscilloscope Module of the AN/UPM-137 was unstable and consequently unusable. A local Tektronix 453 oscilloscope was used as a substitute. A 50 volt potential was present between the OX-16 cabinet and the UPM-137 frame assembly and was reported to local maintenance.

5-3. Environmental Factors

a. Location: The AN/TPX-42 system is collocated with the AN/GPN-12 radar system, 1350 feet northeast of runway 12/30. The ATCRBS omnidirectional antenna is mounted on a pole at the northwest corner of the antenna tower.

b. Reflective Sources: As shown in the panoramic photographs (TABs B-1/4), fences and hangar structures are not prevalent in the immediate area surrounding the ATCRBS antenna and should not adversely affect the performance of the ATCRBS system.

c. Weather: The weather conditions mentioned in paragraph 4-3b also apply to the ATCRBS evaluation.

5-4. Evaluation Profile: The evaluation consisted of a ground phase and a flight phase. The objectives and methods followed to meet those objectives are explained in the following paragraphs.

a. Ground Phase:

(1) To ensure equipment performance had no adverse effects on the evaluation results, extensive equipment checks were performed to verify that system parameters met technical order specifications.

(2) To determine the low power mode transmitter power outputs to be evaluated during the flight phase.

(3) To ensure proper equipment performance during the flight phase, pre and post flight equipment checks were performed.

b. Flight Phase: The flight phase was accomplished by monitoring the ATCRBS replies from the C-140 flight inspection aircraft throughout the ASR flight phase and by monitoring targets of opportunity. The C-140 transponder specifications at the antenna were: transmit power approximately 283 Watts; receiver sensitivity approximately -66 dBm. The flight phase objectives are stated below.

(1) To evaluate the effectiveness of the gain time control (GTC) curve in reducing ring-around and false targets, aircraft replies were observed with the GTC on and off.

(2) To find the lowest transmitter power output required to cover the Williams control area, aircraft replies were scored at 6400 feet MSL on the 230 radial from the Chandler VORTAC using the transmit power outputs determined during the ground phase.

(3) To document the vertical profile of the antenna beam pattern, the aircraft was flown at selected altitudes along the Chandler VORTAC 230 radial.

5-5. Analysis of Evaluation Results

a. Vertical Profile: ATCRBS coverage extended well beyond the control area at every altitude (See TAB F-6) but did have several holes. These loss of ATCRBS targets can be attributed to one or more of the following causes: transponder lock-out, reply rate limiting, aircraft antenna systems, or multipath interference.

(1) Transponder Lock-Out: This is a characteristic of the aircraft transponder which is more noticeable in areas where more than one station, such as Phoenix Approach Control, Albuquerque Air Route Traffic Control Center, Luke GCA, and Williams GCA are all interrogating the aircraft simultaneously. As the aircraft can only respond to one interrogation at a time, all others are locked out of its receiver. This occurs for the duration of the coded reply transmission, plus an additional; period of not more than 125 microseconds. Thus, an ATCRBS return may be lost occasionally because the aircraft is responding to another station.

(2) Reply Rate Limiting: This too is a characteristic of the aircraft transponder which occurs in areas of dense ATCRBS coverage. An Automatic Overload Control (AOC) in the aircraft transponder protects the transmitter section from overloading by reducing reply density based upon received signal strength. AOC levels in the transmitter are normally set to 1200 replies per second. Above this level, receiver sensitivity is reduced to discriminate against interrogations from weaker sources. The AOC system enables the transponder to reduce replies due to low level sidelobes, reflections, and the more distant stations. Since Williams AFB is in an area of numerous ATCRBS facilities, this phenomenon could be prevalent.

(3) Aircraft Antenna Systems: Some modern aircraft use sophisticated antenna systems. The location of the antenna and type of system can affect ATCRBS replies.

(a) Replies can be lost because the aircraft, wings, or landing gear shield the antenna. This usually occurs when the aircraft is climbing, descending, or maneuvering for landing.

(b) Some aircraft use a dual antenna system where the aircraft can choose between two separate antennas, one located at the front of the aircraft and one at the rear, or it can alternate between them at some set rate. If the aircraft is between the chosen antenna and the radar station, interrogations may be blocked from the antenna, and therefore from the aircraft transponder.

(4) Multipath Interference: Multipath interference in the ATCRBS system occurs under the same general conditions as the ASR system (see para 4-5f(3)). The theoretical nulls predicted for the 230 radial are shown in TAB C-4-1 and compared with the actual holes on the 230 radial in Table 5-1. As can be seen, the majority of the holes correlate closely with the theoretical null pattern.

TABLE 5-1
NULLING ANALYSIS (230 RADIAL)

ALTITUDE (feet MSL)	NULL LOCATION Theoretical	Actual
2400	7.0	Weak 7
	12.0	Weak 12
4400	18.0	None
	30.0	Hole 30-32
6400	20.5	Hole 18-20
	29.0	Hole 26-30
	45.0	Hole 43-51

(5) Therefore, holes in the ATCRBS coverage of the Williams Control Area will normally be caused by nulling. However, because the terrain generally slopes up in the northeastern and southeastern quadrants and slopes down in the northwestern and southwestern quadrants, the actual nulling hole location will vary greatly from quadrant to quadrant. Therefore, TAB C-4-2 predicts the nulling holes on the 079 radial. This, combined with TAB C-4-1, should allow the local unit to predict where nulling will occur throughout the control area.

b. Mode/Code Processing: Mode/Code processing was monitored throughout the evaluation. In all cases, the mode/code presentation was correct.

c. False Targets

(1) False targets due to reflections appear when the interrogation main beam energy bounces off of a reflective surface and thus interrogates the aircraft via a reflected path. The aircraft reply usually follows the same path and is received by the main beam of the antenna. Thus, the aircraft reply is displayed on the PPI at the azimuth of the reflective surface and at a greater range than the true target. False targets due to reflections did not occur at any time during the evaluation. The probable reason for this is that the type of terrain surrounding the site was not conducive to reflections.

(2) False targets also appear when the aircraft transponder replies even though the aircraft is outside the main energy beam causing what is commonly referred to as "ring-around". Ring-around was observed when the GTC was turned off. With the GTC on, the ring-around was eliminated.

d. Output Power: In accordance with TO 31P4-2TPX42-6WC-1, the transmitter power was adjusted to lower settings to determine the lowest power output for the required coverage (60 NM). A power setting of approximately 200 watts at J5 of the OX-16 resulted in full range tracking to 60 NM at most altitudes. However, as shown in paragraph 5-5a(4) several holes due to nulling were present. These holes were present even when the high power mode was selected. Therefore, 200 watts was considered optimum.

e. GTC: The "as found" GTC curve was compared to the curve used by TRACALS evaluation teams at most sites. The "as found" curve (see TAB E-2-2) limited inner fringe coverage to 5 NM at 6400 feet MSL. The curve illustrated in TAB E-2-2 was evaluated and provided inner fringe coverage to 2 NM at 6400 feet MSL. Therefore, this curve is considered optimum for present operations.

f. Defruiter: The purpose of the defruiter is to eliminate asychronous replies (aircraft replies from interrogations by surrounding ATCRBS facilities). To help eliminate these replies, and to help prevent overloading the VSP memory, the defruiter should be used.

g. Maximum Range Switch: This switch should be placed in the 60 NM position to help prevent overloading of VSP memory. If ATCRBS targets beyond 60 NM are required, the maximum range switch can be adjusted as necessary.

5-6. Configuration Selection

a. Transmitter: The recommended low power mode output power is 200 watts measured at J5 on the top of the OX-16 cabinet.

b. Gain Time Control: The GTC curve should be in continuous use and aligned in accordance with TO 31P4-2TPX42-2. The curve attenuation should be adjusted as specified in TAB E-2-2.

c. Defruiter: The defruiter should be on for normal operations.

d. Video Signal Processor: The VSP switch should be set as indicated in TAB E-22.

e. Maximum Range Switch: This switch should be in the 60 NM position.

5-7. Capabilities and Limitations: The ATCRBS system is fully capable of performing its assigned ATC mission, but is limited by nulling holes primarily beyond 20 NM. Misalignment of GTC or operating with the transmitter in high power mode will increase the probability of ring-around and false targets. It must be understood that adjustments to the AN/TPX-42 will not compensate for aircraft transponder malfunctions or misalignment. Before any AN/TPX-42 adjustments are made, it should be established that the problem does not in fact lie with the aircraft transponder. If the AN/TPX-42 is configured as described in paragraph 5-6, no problems should be encountered with ATCRBS performance.

6. POWER FACILITIES

6-1. Equipment details: Primary power for all facilities is supplied by a commercial source. All backup power units are equipped with an automatic changeover unit. The backup power systems are configured as listed in TAB E-3.

6-2. Equipment Status: Just prior to the evaluation, unseasonably heavy rains caused the main transformer feeding the AN/GPN-12 to short out. As a result, commercial power was being supplied by a backfeeder line that served several other portions of the base. This backfeeder line was supplying commercial power that was very near the lower specification limit (see TAB E-3) and had to be increased to 120V with the variac. When operating on backup power supplied by the emergency generator at 120V input, the fluctuations (see para 4-2b) present on the regulator voltage output were moderately reduced. Therefore, the low input line voltage appeared to be contributing to the fluctuations caused by the voltage regulator. Since the flight phase was completed using unregulated commercial power (see para 4-2b), three recording voltmeters were used to monitor the input line voltage. No abnormal power fluctuations were noted.

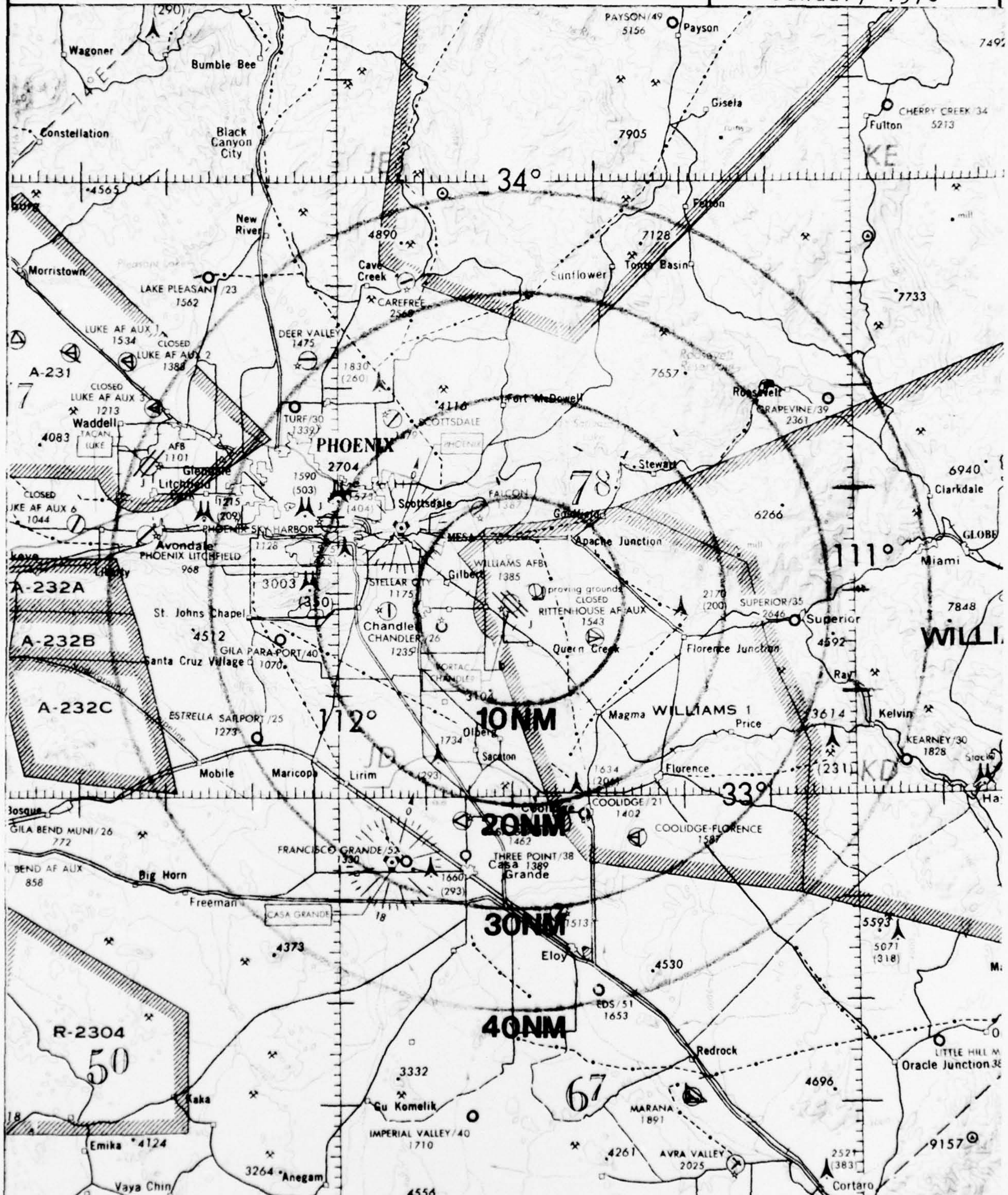
6-3. Adequacy/Reliability: Local maintenance personnel reported that a condition of unreliable commercial power to the AN/GPN-12 site existed before the TRACALS team arrived. The failure of some channel B components such as the AFC module and parametric amplifier could be attributed to the power problems. Although an automatic power changeover capability is incorporated, the backup power generator failed to start when commercial power was lost during the evaluation. Efforts to restore power in the automatic mode were unsuccessful and power was resumed in the manual mode. These problems added to the regulation problems mentioned in paragraph 4-2b, render the primary power to the AN/GPN-12 unreliable.

TITLE:

LOCATION MAP

LOCATION: Williams AFB, AZ

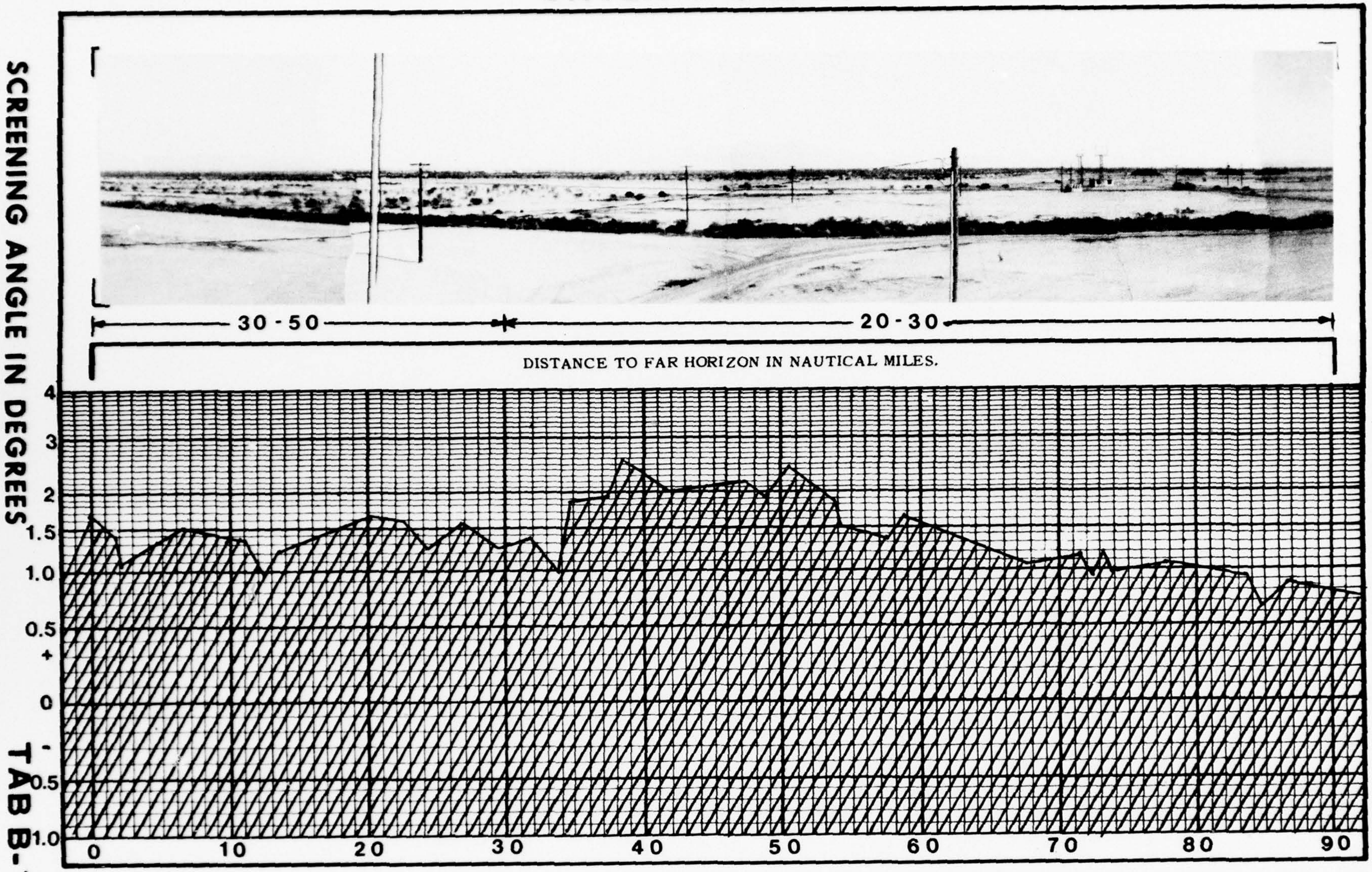
DATE: January 1978



REMARKS

Scale: 1/1,000,000 (Tactical Pilotage Chart)

SKYLINE GRAPH



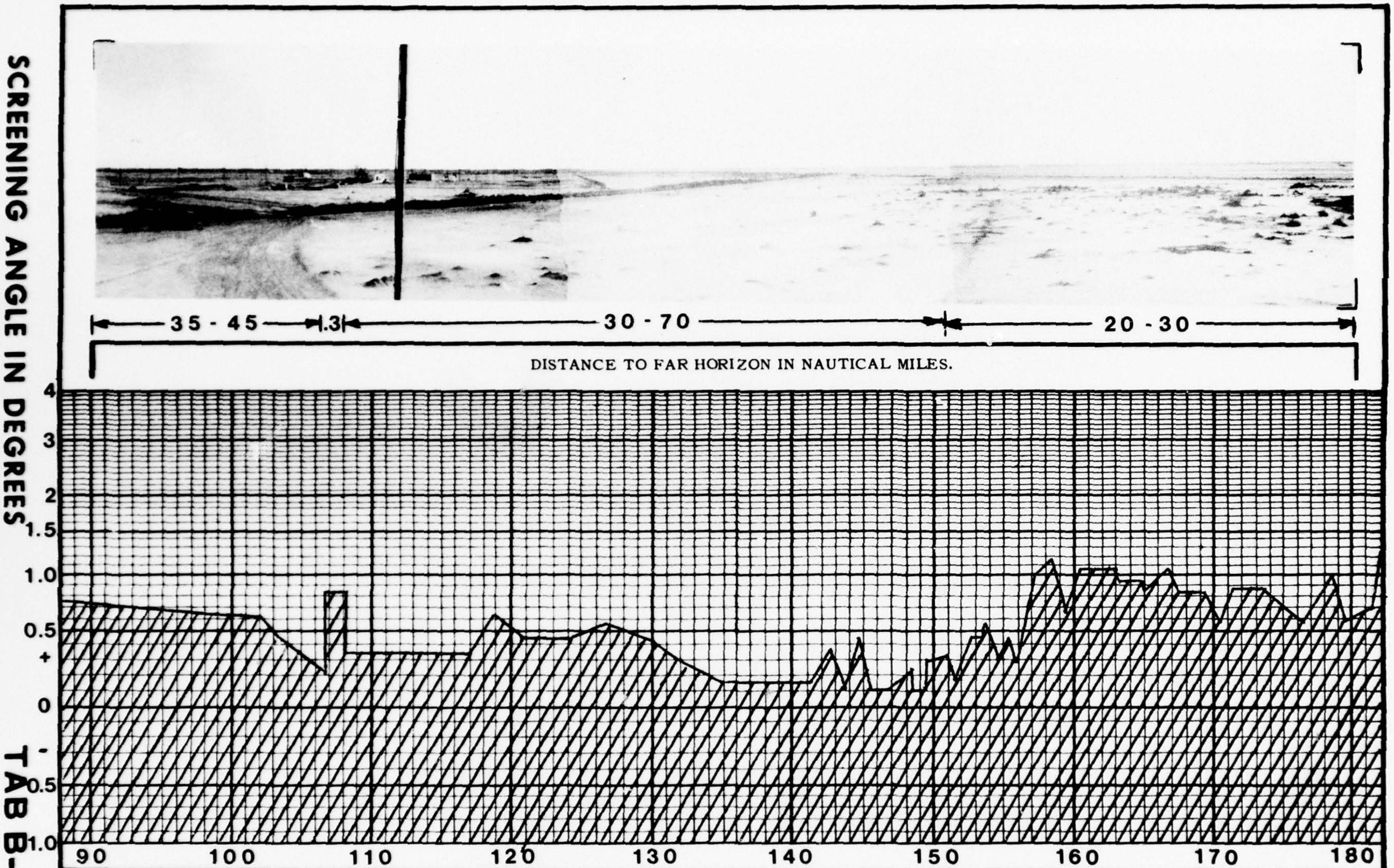
ORIENTED TO: MAGNETIC NORTH
MAG. VAR. 13.2°E

STATION WILLIAMS AFB AZ
EQUIPMENT AN/GPN-12

AFCS FORM MAY 73 913

TAB B-1

SKYLINE GRAPH



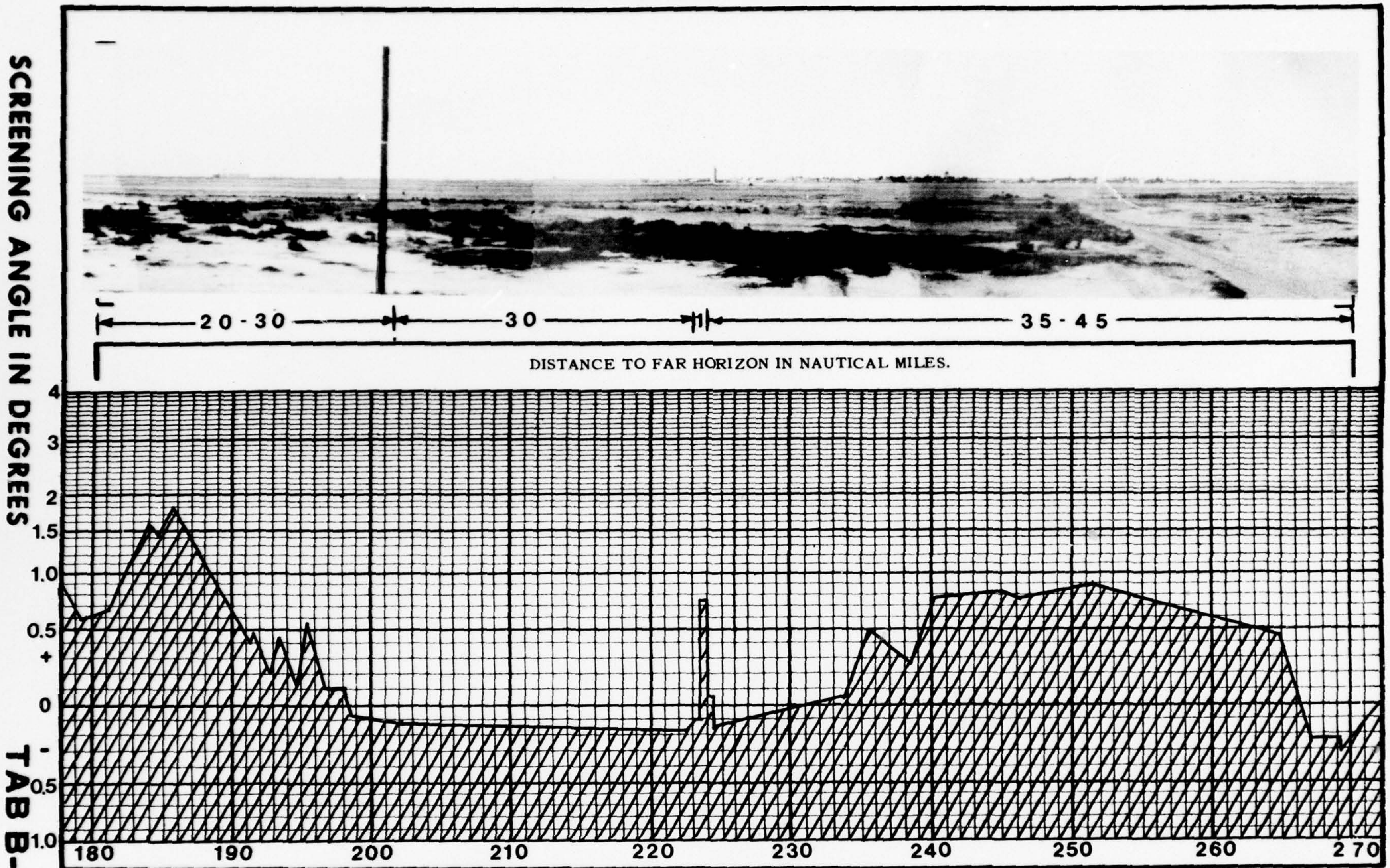
ORIENTED TO: MAGNETIC NORTH
MAG. VAR. 13.2°E

STATION WILLIAMS AFB AZ
EQUIPMENT AN/GPN-12

AFCS FORM MAY 73 913

TAB B-2

SKYLINE GRAPH



TAB B-3

ORIENTED TO: MAGNETIC NORTH

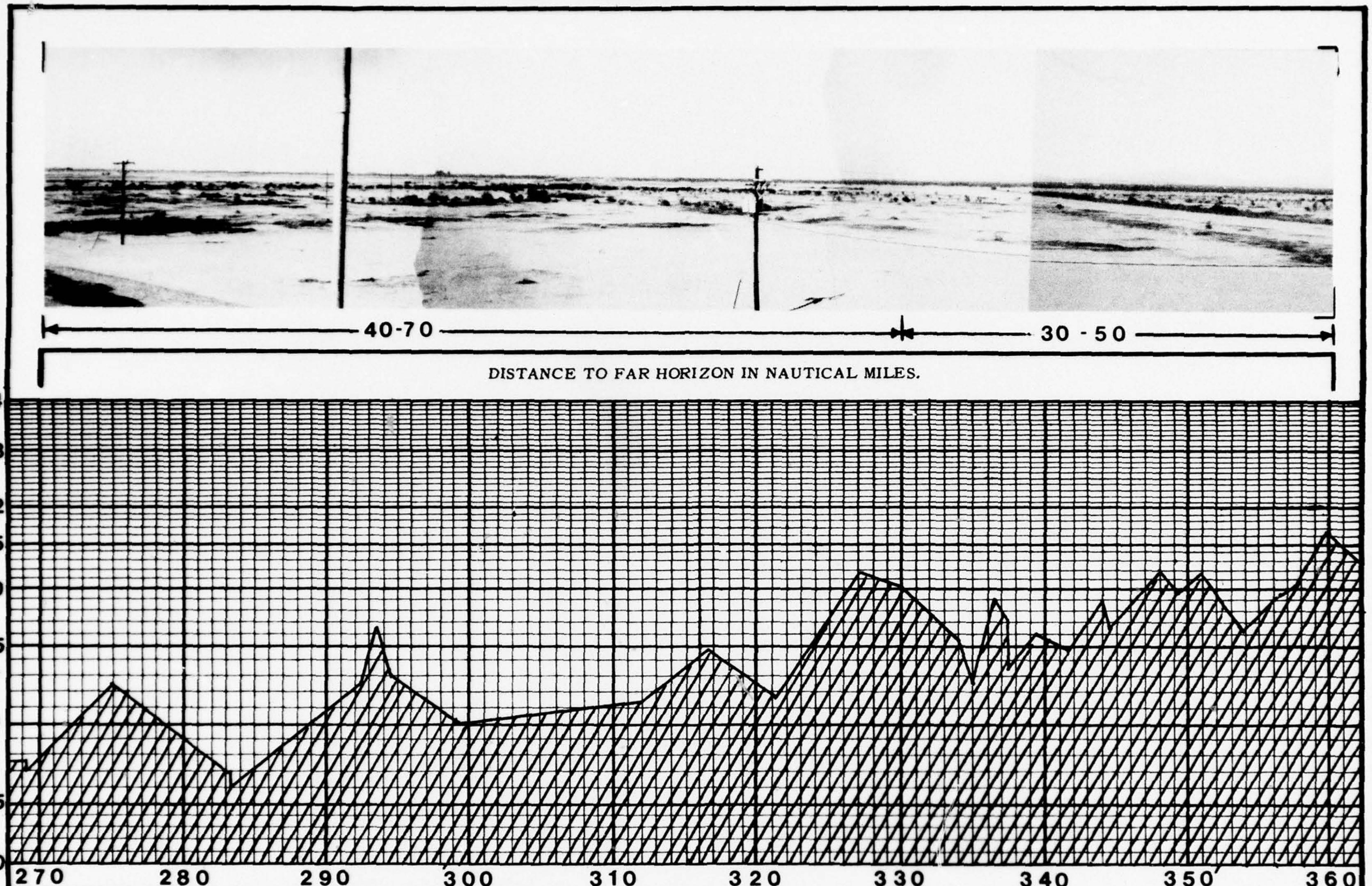
MAG. VAR. 13.2°E

STATION WILLIAMS AFB. AZ

EQUIPMENT AN/GPN-12

AFCS FORM MAY 73 913

SKYLINE GRAPH



SCREENING ANGLE IN DEGREES

ORIENTED TO: MAGNETIC NORTH
MAG. VAR. 13.2°E

STATION WILLIAMS AFB. AZ
EQUIPMENT AN/GPN-12

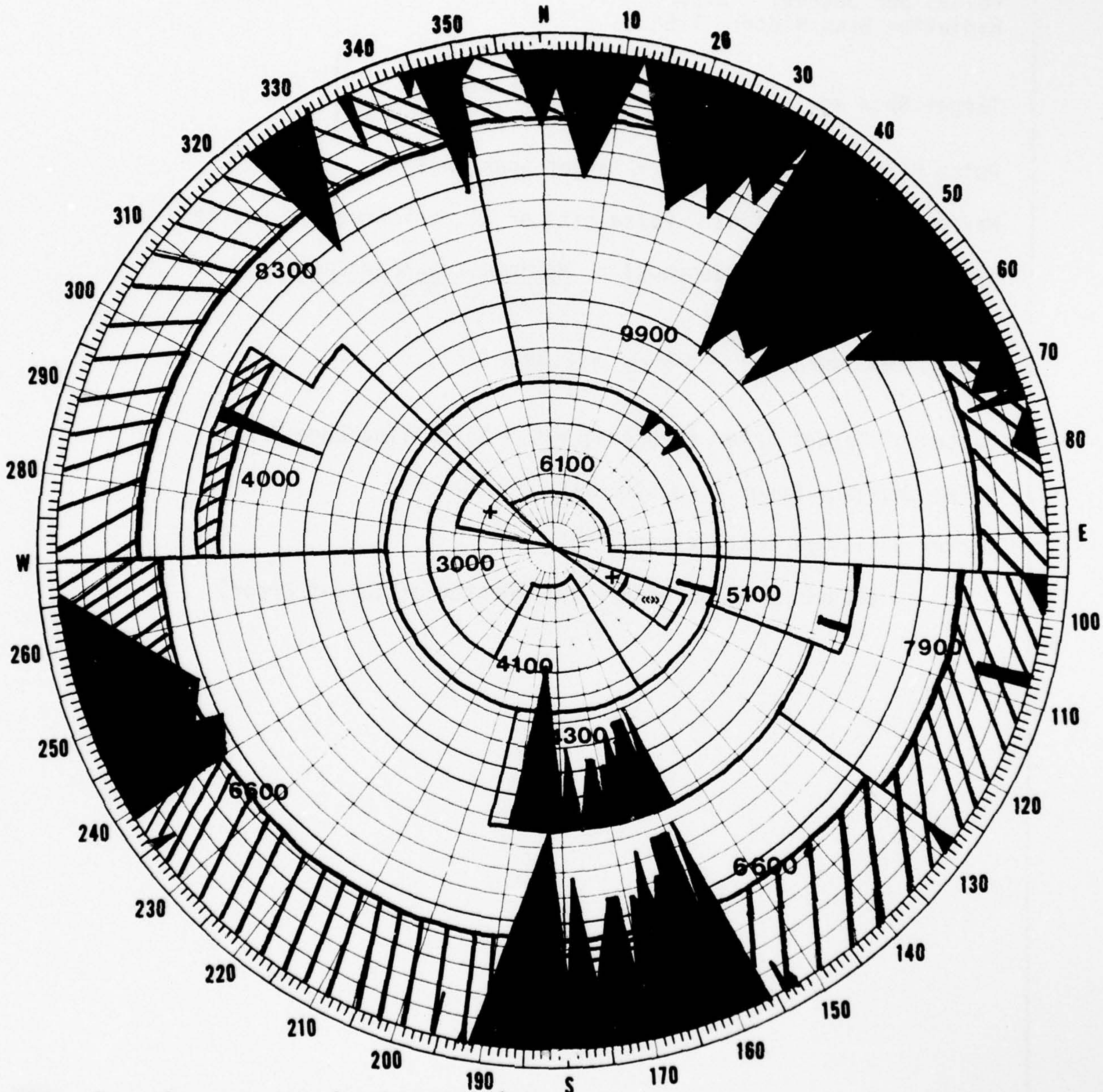
AFCS FORM MAY 73 913

TAB B-4

TITLE:

RADAR COVERAGE AT MINIMUM VECTORING ALTITUDE (MVA)

LOCATION	DATE
Williams AFB, AZ	January 1978



No radar coverage due to screening.

No radar coverage due to maximum range limitations.

REMARKS +: 2600

«»: 2800 THREE MILE RANGE MARKS

AFCS FORM MAY 73 906 GENERAL INFORMATION TAB:C-1

TITLE:

DISPLACEMENT ERROR USING VIDEO ENHANCER

Computation Base

Antenna Rotation: 12.9 RPM or 77.4° per second
Stagger PRF: 1002 PPS
Pulses per Degree: 12.95
Radiation Beam Width: 1.5°

$$\text{Target Span Angle} = \text{Arctan}\left[\frac{\text{Target Width}}{(\text{Range in NM})(6076)}\right]$$

Pulse Hits = 12.95 X (1.5° + Target Span Angle)

Maximum Enhancer Count: Pulse hits or 31, whichever is smaller.

$$\text{Trailing Edge Error (degrees)} = \frac{\text{Maximum Enhancer Count}}{12.95}$$

NOTE: Maximum Error = $\frac{31}{12.95}$ = 2.39

Center of Target Error (degrees) = 0.5 X Trailing Edge Error

NOTE: Maximum Error = (0.5)(2.39) = 1.20

Center of Target Displacement [feet]

= (Range in NM) X 6076 X tan (Center of Target Error)

REMARKS

TITLE

DISPLACEMENT ERROR USING VIDEO ENHANCER

50 Foot Target*

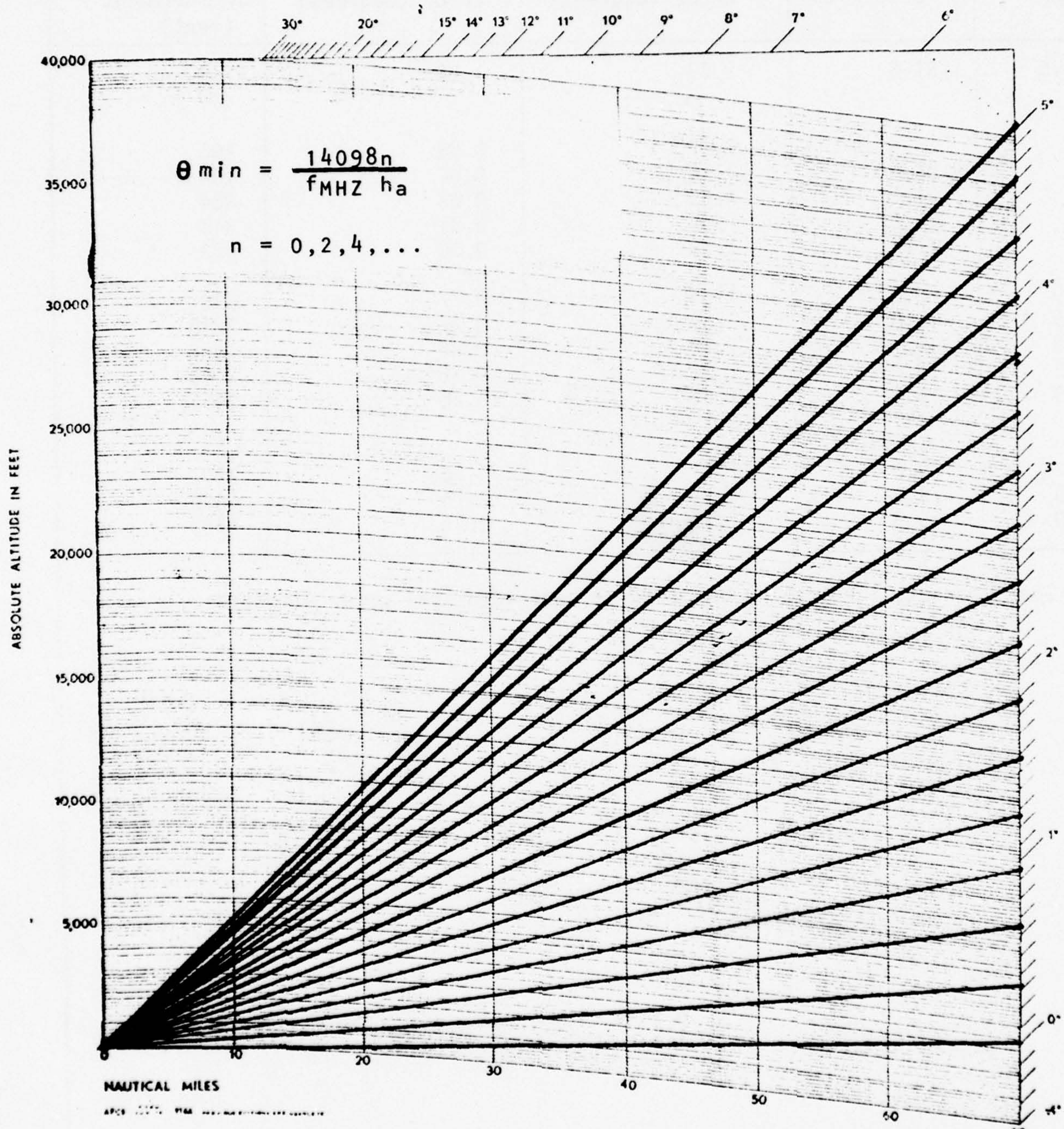
Ranges (NM)	Number of Pulse Hits	Trailing Edge Error (Degrees)	Center of Target Error (Degrees)	Center of Target Displacement (feet)
0.5	31.6	2.39	1.20	63
1	25.5	1.97	0.99	105
2	22.5	1.74	0.87	184
3	21.5	1.66	0.83	264
4	21.0	1.62	0.81	343
5	21.7	1.59	0.80	423
10	20.0	1.55	0.77	820
15	19.8	1.53	0.77	1218
20	19.7	1.52	0.76	1615
25	19.7	1.52	0.76	2013
30	19.6	1.52	0.76	2411
40	19.6	1.51	0.76	3207
50	19.6	1.51	0.75	4002
60	19.5	1.51	0.75	4797

* Ideal target, i.e., all pulse returns have identical power strengths.

REMARKS

ASR NULL ANGLE PREDICTIONS

LOCATION: Williams AFB, AZ	Average elevation of reflecting plane 1362 Ft MSL. $f_{MHZ}=2800$ $h_a=31.9$ ft.
EQUIPMENT: AN/GPN-12	AZIMUTH: 230°

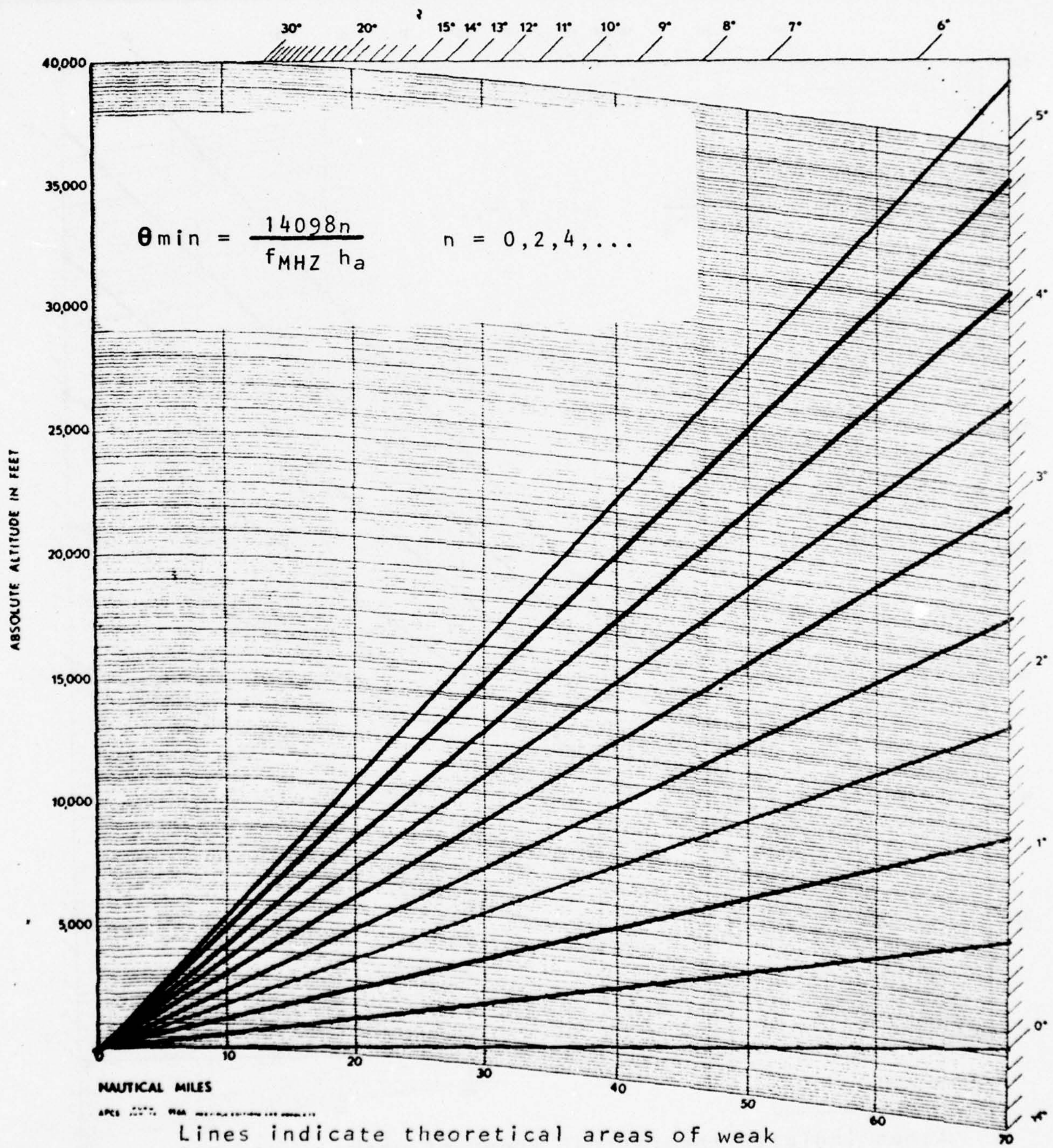


Lines indicate theoretical areas of weak ASR signal due to nulling.

TAB: C-3-1

ASR NULL ANGLE PREDICTIONS

LOCATION: Williams AFB, AZ	Average elevation of reflecting plane 1377 Ft MSL. $f_{MHZ}=2800$ $h_a=16.9$ ft.
EQUIPMENT: AN/GPN-12	AZIMUTH: 079°

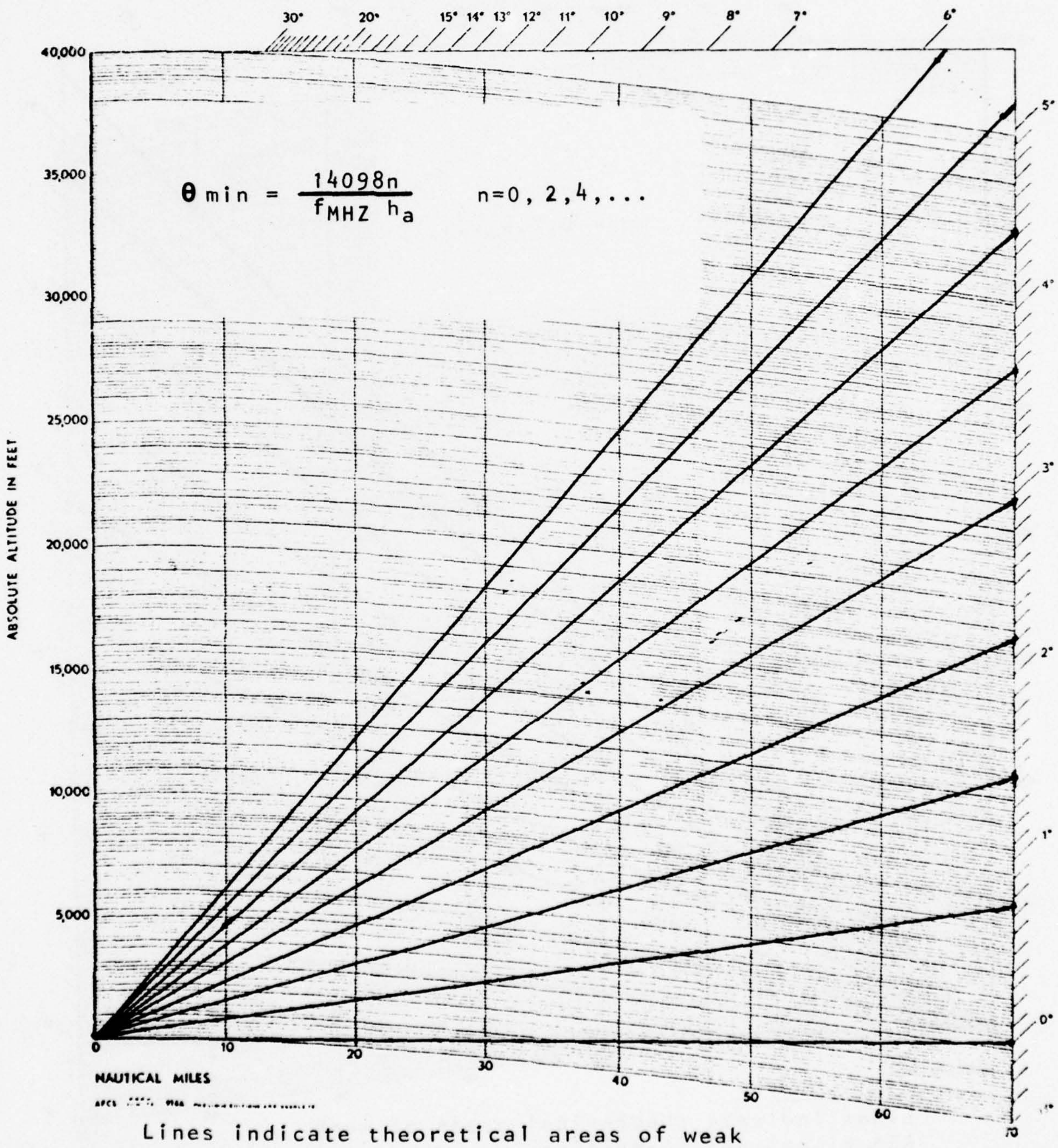


Lines indicate theoretical areas of weak ASR signal due to nulling.

TAB: C-3-2

ATCRBS NULL ANGLE PREDICTIONS

LOCATION: Williams AFB, AZ	Average elevation of reflecting plane 1362 Ft MSL. f_{MHZ} = 1030 h_a = 37.2 ft.
EQUIPMENT: AN/TPX-42	AZIMUTH: 230°

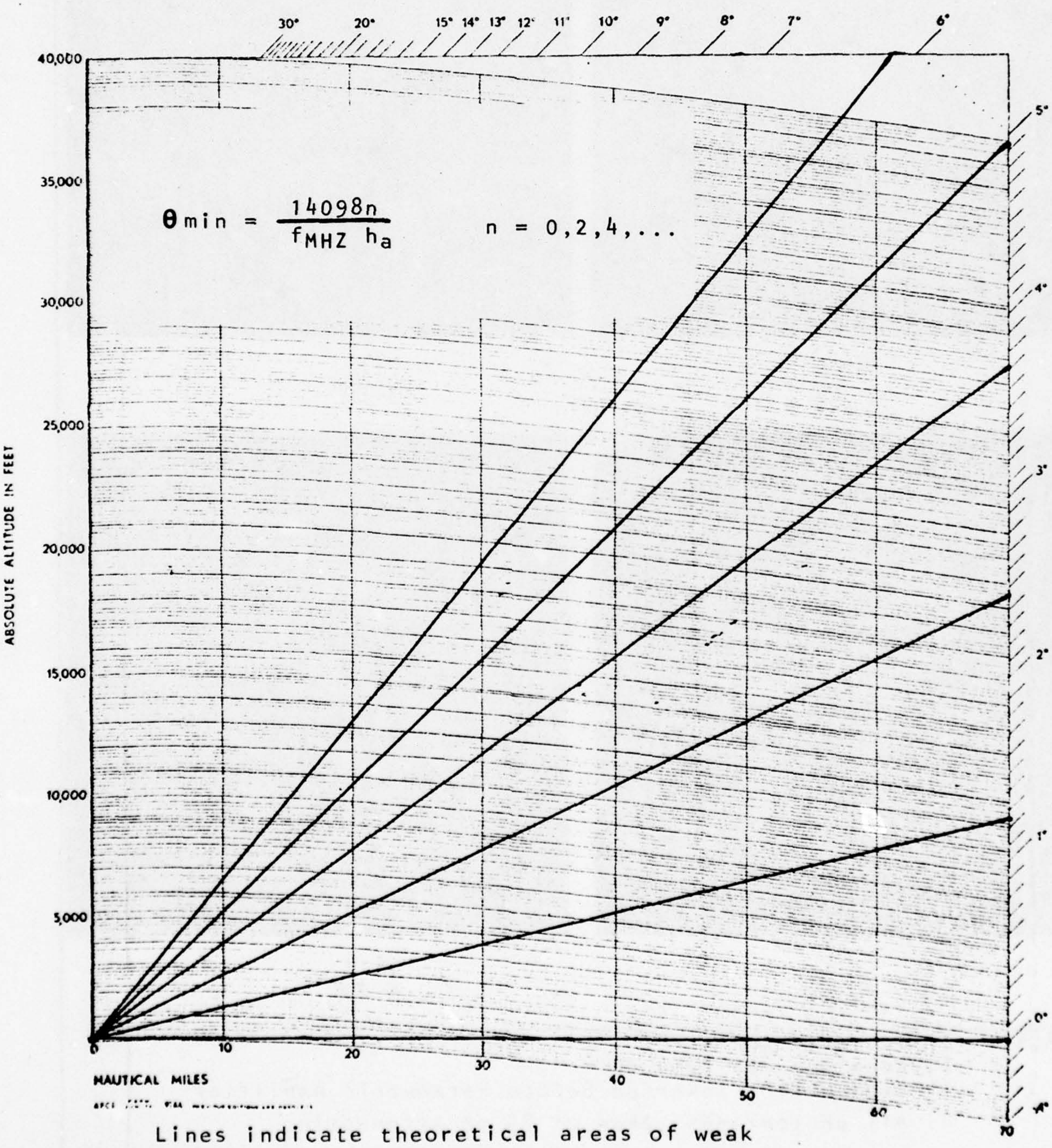


Lines indicate theoretical areas of weak ATCRBS signals due to nulling.

TAB: C-4-1

ATCRBS NULL ANGLE PREDICTIONS

LOCATION: Williams AFB, AZ	Average elevation of reflecting plane 1377 Ft MSL. $f_{MHZ}=1030$ $h_a = 12.2$ ft.
EQUIPMENT: AN/TPX-42	AZIMUTH: 079°



Lines indicate theoretical areas of weak ATCRBS signals due to nulling.

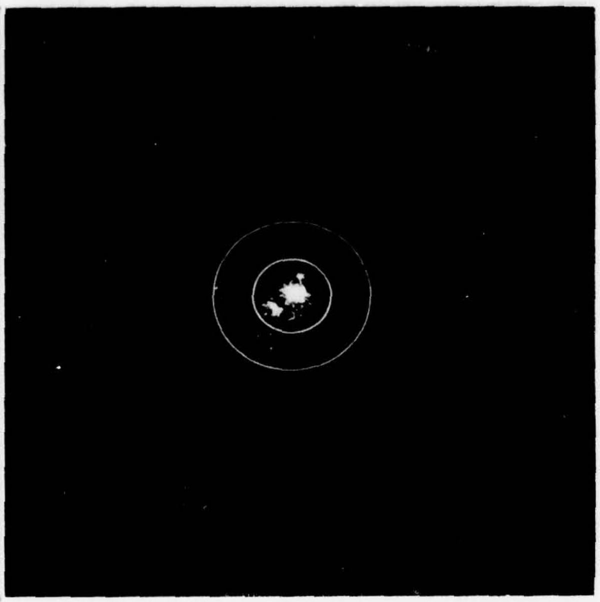
TAB C-4-2

TITLE

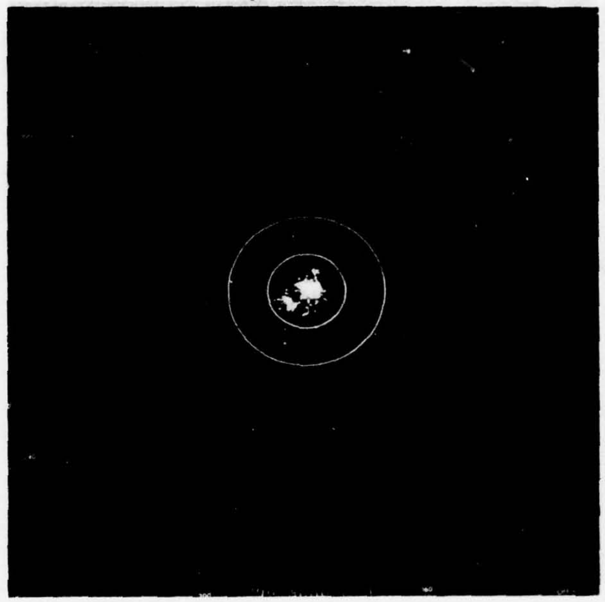
ASR CLUTTER TILT COMPARISON

LOCATION: Williams AFB, AZ

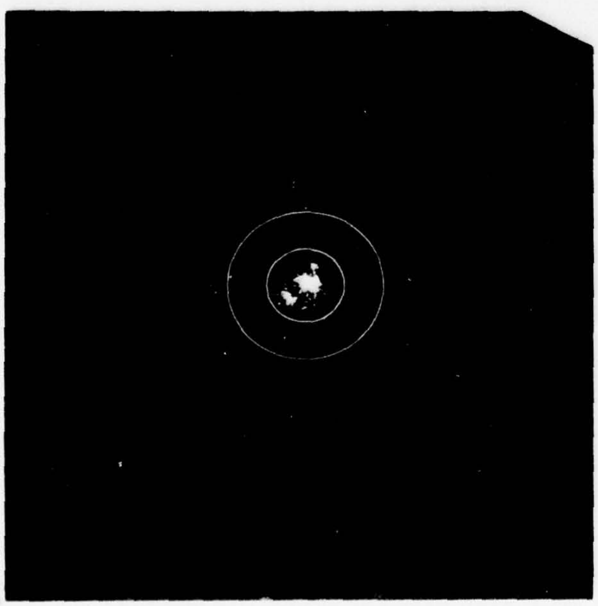
DATE: January 1978



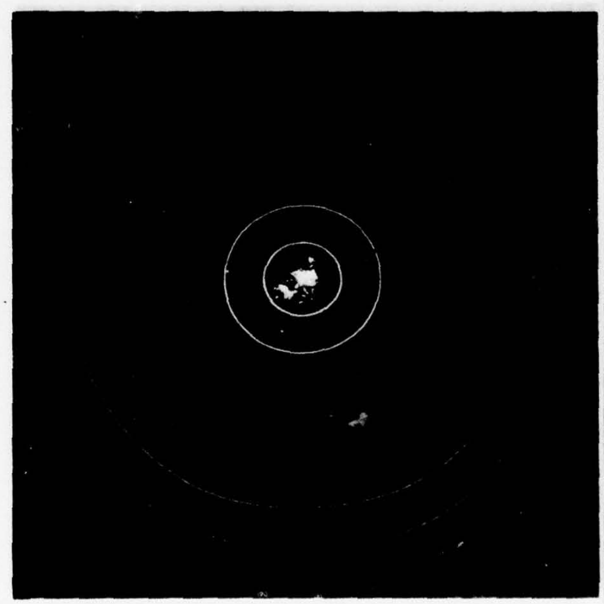
Tilt
3.25°



Tilt
3.50°



Tilt
3.75°



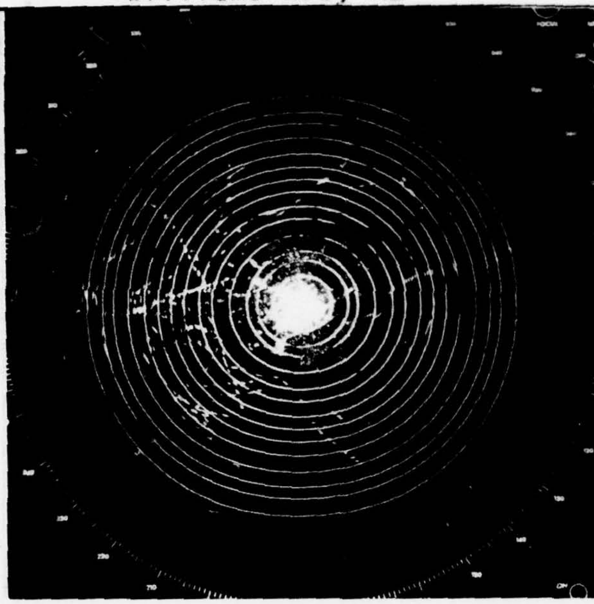
Tilt
4.00°

REMARKS: 1. Scope range 15 NM.
2. Receiver MDS -109 dBm.
3. Attenuation inserted before Parametric Amplifier.
4. All photographs taken at 65 dB attenuation.

TITLE

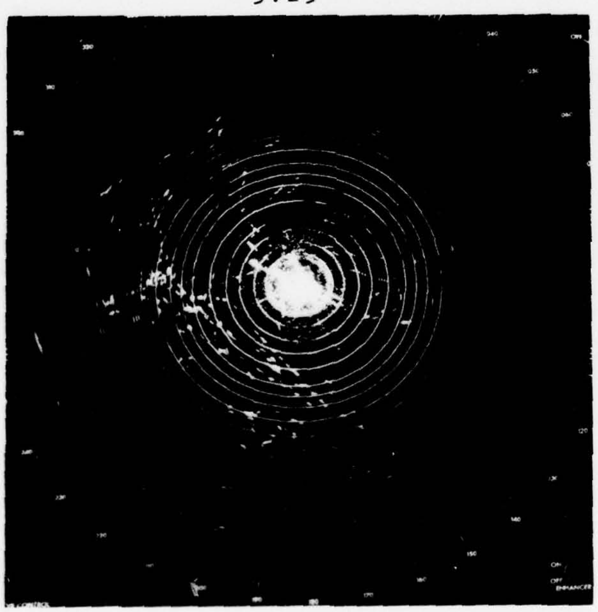
ANNULAR SUBCLUTTER VISIBILITY

LOCATION	DATE
Williams AFB, AZ	January 1978

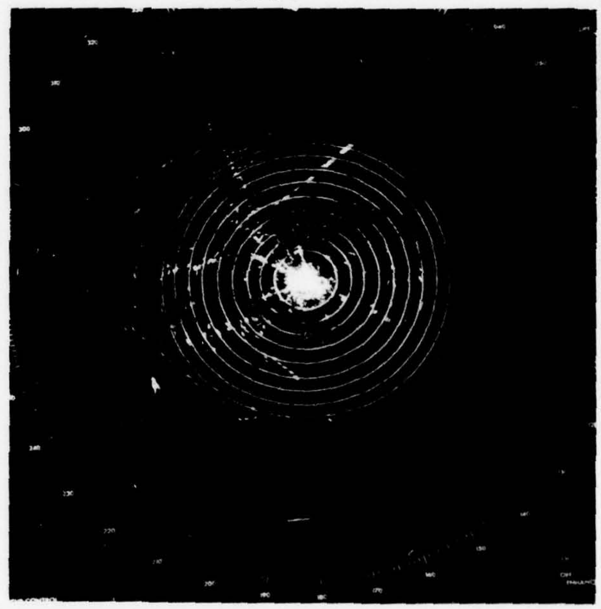


Tilt
3.25°

Tilt
3.50°



Tilt
3.75°



Tilt
4.00°

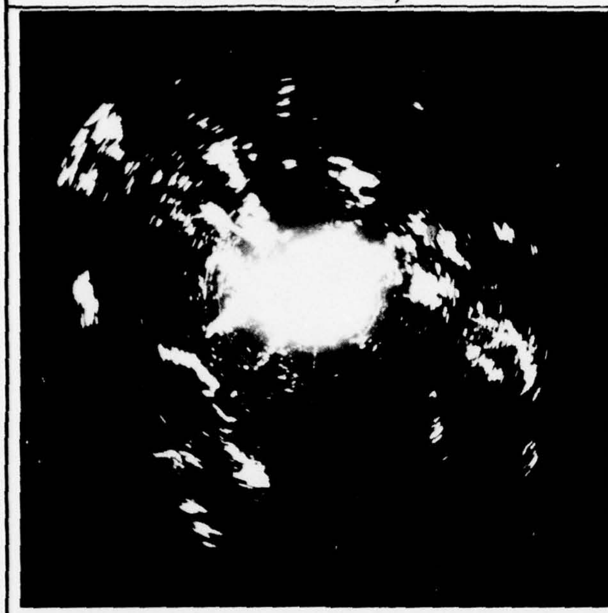
REMARKS:
1. Simulated aircraft, C-140, at 5000 Ft MSL, at displayed range.
2. Inner ring 4 NM, rings 2 NM apart.
3. MTI Gated to 60 NM.

TITLE

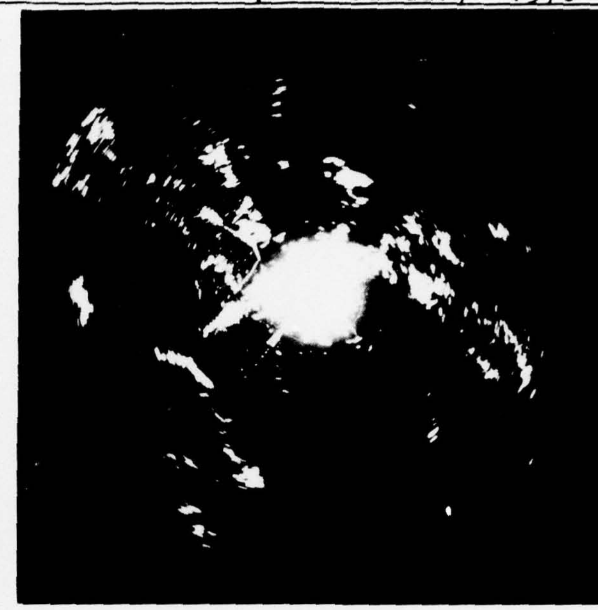
CLUTTER INTENSITY / 3.75° ANTENNA TILT

LOCATION: Williams AFB, AZ

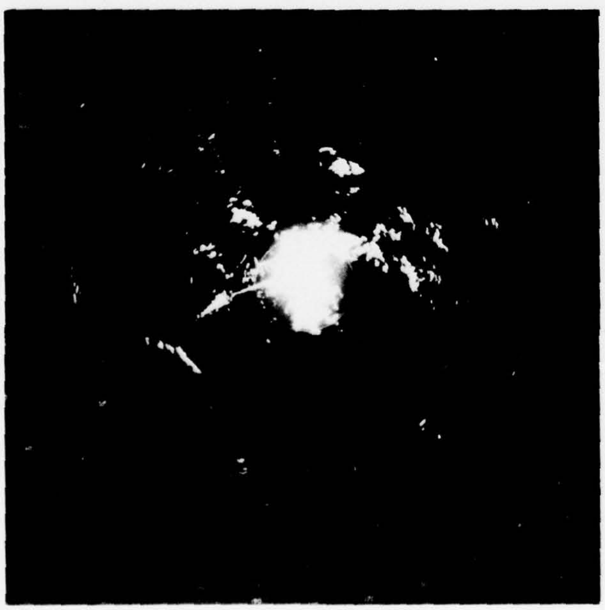
DATE: January 1978



0 dB
60 NM



10 dB
60 NM



30 dB
60 NM

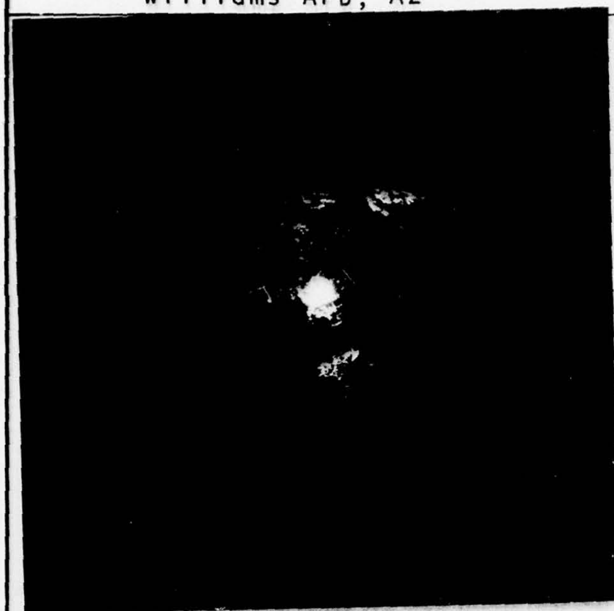
40 dB
30 NM

REMARKS The amount of attenuation required to lose clutter targets is the approximate clutter signal return strength above system MDS (-109 dBm). Attenuation inserted before Parametric Amplifier.

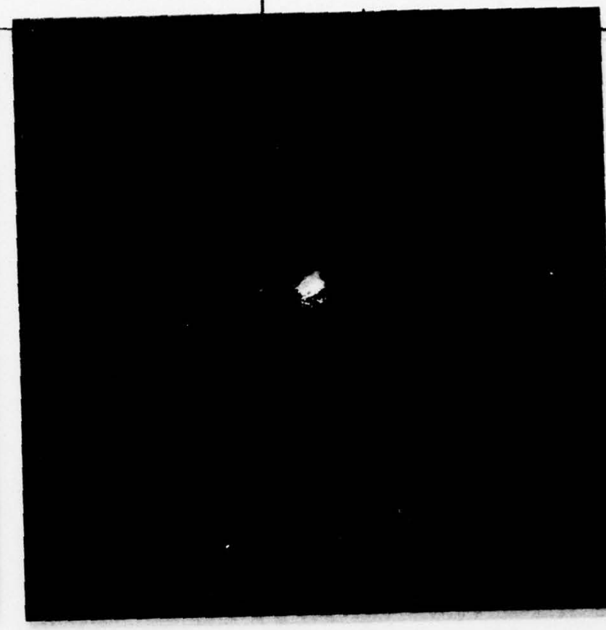
TITLE

CLUTTER INTENSITY / 3.75° ANTENNA TILT

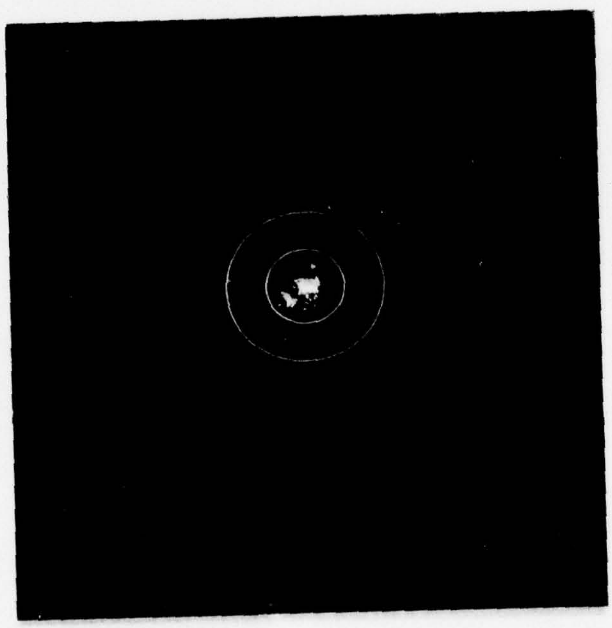
LOCATION	DATE
Williams AFB, AZ	



50 dB
30 NM



60 dB
30 NM



70 dB
15 NM

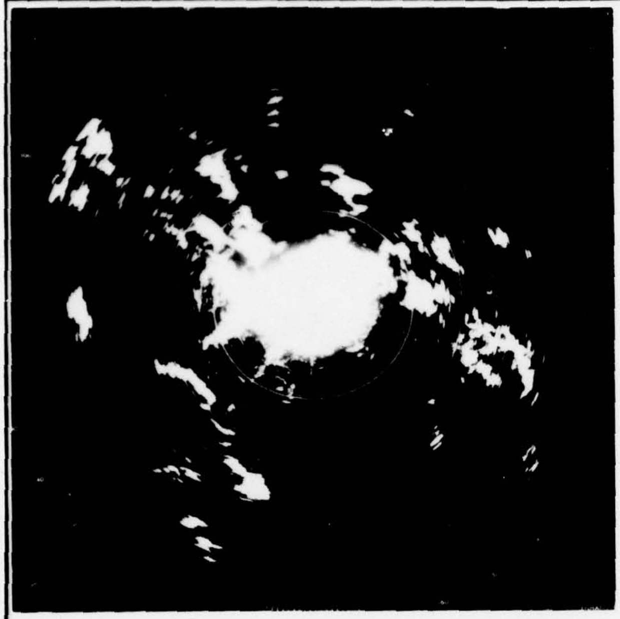
REMARKS The amount of attenuation required to lose clutter targets is the approximate clutter signal return strength above system MDS (-109 dBm). Attenuation inserted before Parametric Amplifier.

TITLE

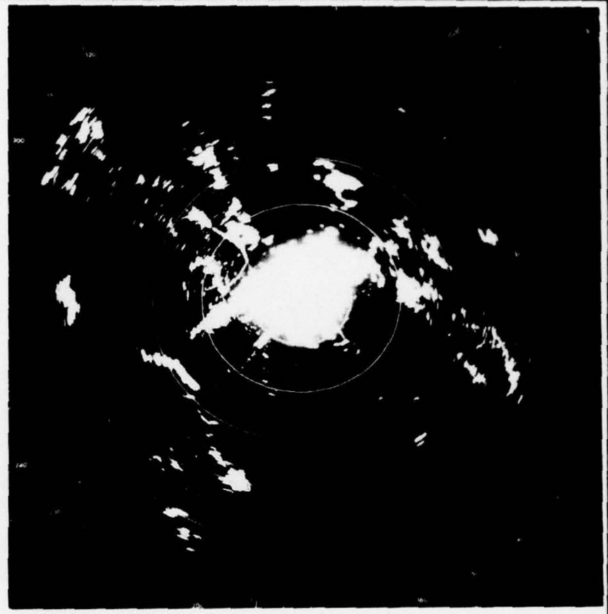
CLUTTER INTENSITY / 3.25° ANTENNA TILT

LOCATION: Williams AFB, AZ

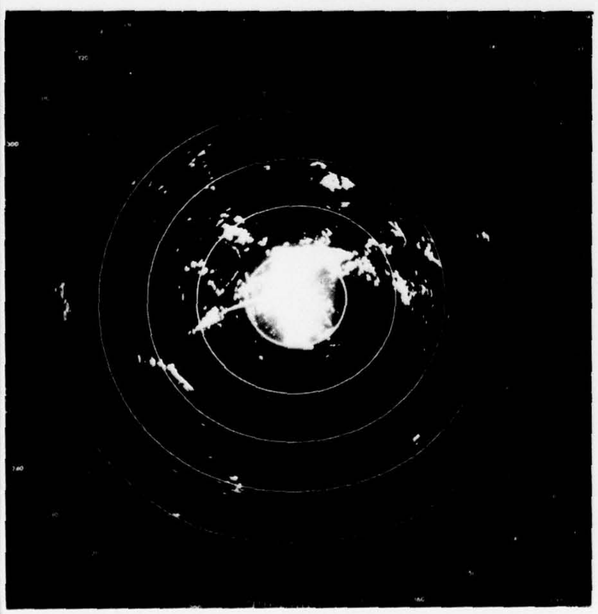
DATE: January 1978



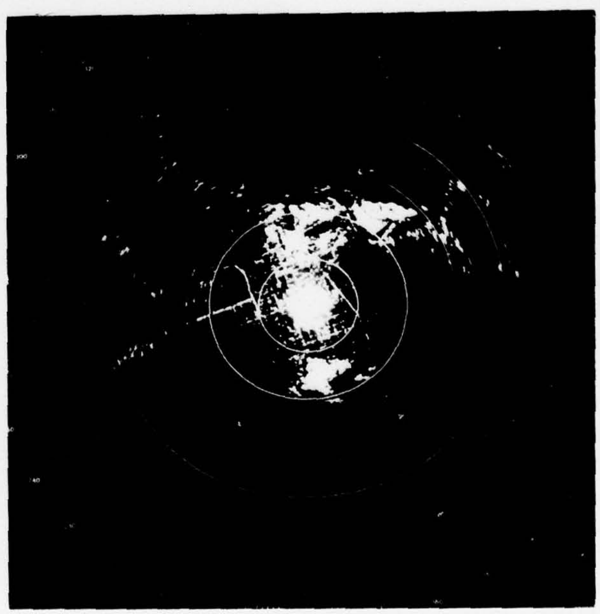
0 dB
60 NM



10 dB
60 NM



30 dB
60 NM



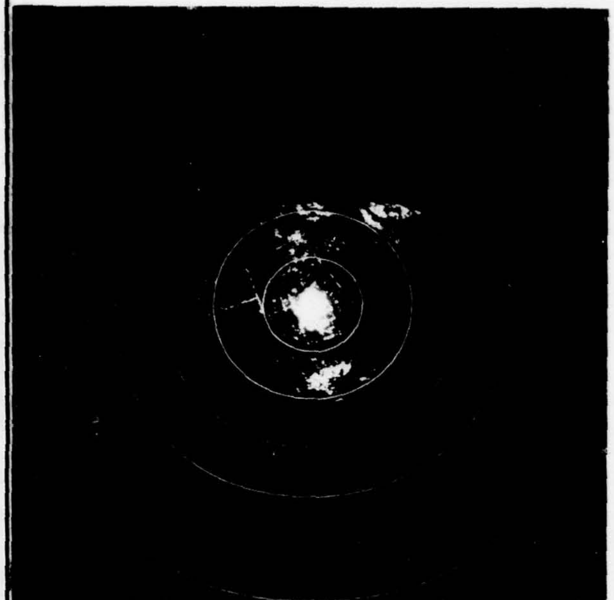
40 dB
30 NM

REMARKS: The amount of attenuation required to lose clutter targets is the approximate clutter signal return strength above system MDS (-109 dBm). Attenuation inserted before Parametric Amplifier.

TITLE

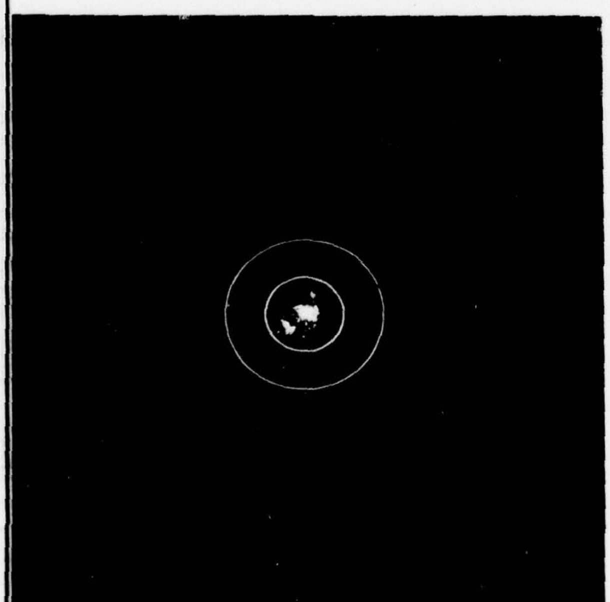
CLUTTER INTENSITY / 3.25° ANTENNA TILT

LOCATION	DATE
Williams AFB, AZ	January 1978

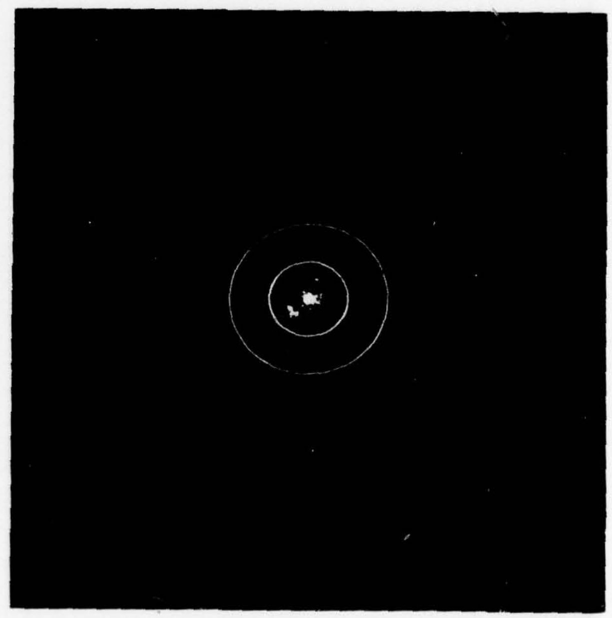


50 dB
30 NM

60 dB
30 NM



70 dB
15 NM



75 dB
15 NM

REMARKS The amount of attenuation required to lose clutter targets is the approximate clutter signal return strength above system MDS (-109 dBm). Attenuation inserted before Parametric Amplifier.

ASR INITIAL PERFORMANCE CHECKLIST AN/GPN-12

LOCATION Williams AFB, AZ	DATE January 1978
ORGANIZATION 1922 Comm. Sq.	TYPE RADAR/SERIAL NUMBER AN/GPN-12 SN: 39

SECTION I. ANTENNA SUBSYSTEM

TYPE ANTENNA ASR-7 / FA-8201	GROUND ELEVATION 1369.6 Ft MSL
SERIAL NUMBER 1025 (NOTE 1)	HEIGHT TO FOCAL POINT 26.0 Ft AGL

CHECK		SPECIFICATIONS	CHECK RESULTS	
			INITIAL	READJUSTED
1. ANTENNA ASSEMBLY		SERIAL NUMBERS MATCH INSTALLATION DATA	3051	
2. PEDESTAL		LEVEL	± 1'	
3. FEEDHORN ALIGNMENT		TELESCOPE CROSS HAIRS WITHIN TOLERANCE CIRCLES		
4. FEEDHORN MEASUREMENTS		ANGLE	7 1/32"	
		ELEVATION	4 15/16"	
		FOCUS	2 1/16"	
5. TILT		MECHANICAL	3.75	
		ELECTROMAGNETIC (TRUE)	3.65	
6. AZIMUTH RING ORIENTATION		MAGNETIC NORTH Ø ± 0.5 DEGREES	4.5° East of Magnetic North	See TAB E-1-7/8
7. ROTATION SPEED (RPM)			13	

SECTION II. TRIGGERING SUBSYSTEM

	AMPLITUDE	WIDTH	A		B		A		B	
1. 1A1J3 MOD TRIG	5 ± 1.5 V	0.5 ± 0.1 USEC	5.0	0.5						
2. 2A6 DISPLAY TRIG	5 ± 1.5 V	0.5 ± 0.1 USEC	5.0	0.5						
3. 2A6 STC TRIG	5 ± 1.5 V	0.5 ± 0.1 USEC	5.0	0.5						
4. 2A6 MOD TRIG	5 ± 1.5 V	0.5 ± 0.1 USEC	5.0	0.5						
5. 7A4A1A1TP4 DISPLAY TRIG	5 ± 1.5 V	0.5 ± 0.1 USEC	4.5	0.5						
6. 7A4A1A1TP4 BEACON TRIG	5 ± 1.5 V	0.5 ± 0.1 USEC	6.0	0.5						

SECTION III. TRANSMITTER SUBSYSTEM

CHECK	SPECIFICATIONS	CHECK RESULTS			
		INITIAL		READJUSTED	
		A	B	A	B
1. STAGGER PRF	1002 (PPS)	1002			
2. MAGNETRON * FILAMENT VOLTAGE	OPERATE: 8.0 ± 0.4 VDC	8.0			
	STANDBY: 15.5 ± 0.5 VDC	15.8			
3. MOD DRIVER CURRENT	35 ma MAX	29.0			
4. PULSE WIDTH	0.833 USEC AT 70% OF MAX AMPLITUDE	0.833			

SECTION III. TRANSMITTER SUBSYSTEM

CHECK	SPECIFICATIONS	CHECK RESULTS INITIAL A	INITIAL B	READJUSTED A	READJUSTED B
5. MAGNETRON SPECTRUM	WIDTH: 2.5 MHZ ± 10%	2.17		2.60	
	FIRST SIDELOBE 8 dB MIN	10.5		10.0	
6. TRANSMITTER FREQUENCY	ASSIGNED FREQUENCY ± 1.4 MHz : 2820	2820			
7. DUTY CYCLE	(PW) X (PRF) (Stagger On)	0.000835			
8. TRANSMITTER VOLTAGE	7.6 KV NOMINAL	8.5		7.8	
9. TRANSMITTER CURRENT	60 THRU 180 ma	140		120	
10. MAGNETRON CURRENT	40 ma NOMINAL	39.0		30.5	
11. MOD INVERSE CURRENT	20 ma MAXIMUM	9.8		4.0	

CHECK	SPECIFICATIONS	Comparator in	out			Comparator in	out		
12. AVERAGE PWR STAGGER	NOTE 3								
A. INCIDENT POWER	55.5 dB MINIMUM COMPARATOR OUT	55.45	55.9			55.0	55.68		
B. REFLECTED POWER		LP 37.0	CP 36.5						
C. DIFFERENCE (A-B)	15.56 dB MINIMUM	18.0	19.18						
D. VSWR	1.4:1 MAXIMUM	1.29	1.25						
13. AVERAGE PWR (1200 PRF)	56.28 dBm COMPARATOR OUT	56.4	56.6			55.06	56.28		

SECTION IV. RECEIVER SUBSYSTEM

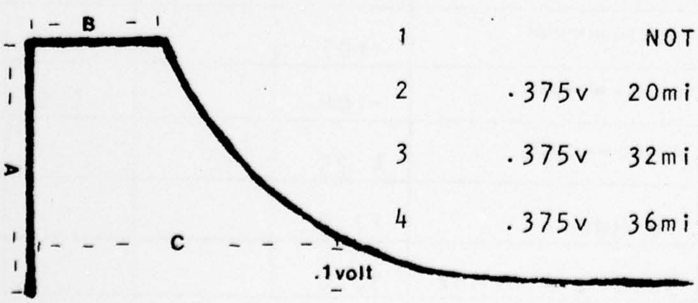
CHECK		SPECIFICATIONS	INITIAL A	INITIAL B	READJUSTED A	READJUSTED B
1. AFC OPERATION		PROPER INDICATION ON TUNING METER	Jittery		Sat	
2. POSITIVE RECEIVER CRYSTAL CURRENT		0.6 TO 0.9 ua	0.72		0.88	
3. NEGATIVE RECEIVER CRYSTAL CURRENT		0.6 TO 0.9 ua	0.58		0.87	
4. PARAMP GAIN		+ 15 dB NOMINAL	29		15	
5. NOISE FIGURE		4.7 dB MAXIMUM	4.6		4.4	
6. NORMAL SENSITIVITY		-108 dBm MINIMUM	-106		-110	
7. MTI SENSITIVITY		-106 dBm MINIMUM	-107		-108	
8. NORMAL LOG SENSITIVITY		-106 dBm MINIMUM	-107		-108	
9. MTI LOG SENSITIVITY		-104 dBm MINIMUM	-104		-105	
10. T/R RECOVERY TIME		7 USEC MAXIMUM	4.75			
11. PREAMP NORMAL	BANDWIDTH	10 MHz	12.0			
	CENTER FREQUENCY	30.0 ± 1.0 MHz	30.0			
	GAIN	30 dB	42			

AFCS FORM 909A

SECTION IV.	RECEIVER SUBSYSTEM					
CHECK		SPECIFICATIONS	CHECK RESULTS			
			INITIAL		READJUSTED	
			A	B	A	B
12. PREAMP MTI	BANDWIDTH	10.0 MHz	12.0			
	CENTER FREQUENCY	30.0 ± 1.0 MHz	30.0			
	GAIN	30 dB	42			
13. NORMAL IF AMP	BANDWIDTH	2.4 ± 0.3 MHz	2.5			
	CENTER FREQUENCY	30.0 ± 0.1 MHz	30.0			
	GAIN	60 dB	58			
14. MTI IF AMP	BANDWIDTH	5.5 ± 0.55 MHz	7.3		5.2	
	CENTER FREQUENCY	30.0 + 0.1 MHz	27.6		30.0	
	GAIN	SPECIFICATION NOT ESTABLISHED	46		46	
15. NORMAL LOG IF	BANDWIDTH	2.2 ± 0.3 MHz	2.6			
	CENTER FREQUENCY	30.0 ± 0.1 MHz	30.0			
	GAIN	70 dB	69			
16. MTI LOG IF	BANDWIDTH					
	CENTER FREQUENCY					
	GAIN					
17. VIDEO ENHANCER GAIN	NORMAL	13 dB MINIMUM	14			
	MTI	13 dB MINIMUM	16			
18. CANCELLATION RATIO		30 dB MINIMUM	30+			
19. SUBCLUTTER VISIBILITY		25 dB MINIMUM	26			

20. STC WAVESHAPES

(NOTE 2)



STC	"A"	"B"	"C"
1	NOT AVAILABLE		
2	.375v	20microsec	60microsec
3	.375v	32microsec	60microsec
4	.375v	36microsec	86microsec

SECTION V. REMOTING SYSTEM											
CHECK	SPECIFICATIONS	CHECK RESULTS									
		AMPLITUDE				WIDTH				DISTORT	
		A	B	A	B	A	B	A	B	A	B
1. NORMAL											
A. RLD IN	2.0 V, 1.0 USEC	2.0				1.0				0	
B. RLD OUT	6.0 V, 1.0 USEC	6.0				1.0				0	
C. RLA IN *		3.2				3.0				HF	
D. RLA OUT	5.0 V, 1.0 USEC MINIMUM DISTORTION	6.0		5.0		1.0				0	
2. MTI											
A. RLD IN	2.0 V, 1.0 USEC	2.0				1.0				0	
B. RLD OUT	6.0 V, 1.0 USEC	6.0				1.0				0	
C. RLA IN *		3.2				3.0				HF	
D. RLA OUT	5.0 V, 1.0 USEC MINIMUM DISTORTION	4.5		5.0		1.0				0	

SECTION VI. INDICATOR SUBSYSTEM					
1. PPI		ASR 1	ASR 2	ASR 3	ASR 4
A. MDS DIFFERENTIAL	0 dB LOSS BETWEEN INDICATOR AND RECEIVER	0	0	0	0
B. SWEEP STABILITY	NO SWEEP JITTER AND NO OVERLAP	Sat	Sat	Sat	Sat
C. AZIMUTH ORIENTATION	0 ± 1.0 DEGREE FROM ANTENNA ORIENTATION	Sat	Sat	Sat	Sat
2. RANGE MARK INTERVAL	12.36 USEC BETWEEN PULSES	Sat	Sat	Sat	Sat
3. SWITCHES AND FUNCTIONS	SATISFACTORY OPERATION	Sat	Sat	Sat	Sat

SECTION VII. REMARKS

* *The amount of signal loss and distortion is dependent upon the distance between the local and remote sites.*

Note:

1. All antenna system subcomponents have the serial number 3051.

2. STC-1 was used during the flight phase. The STC graph is shown using a 10:1 probe, .1 v/cm, 20 usec/div.

3. The listed average power readings under section III, item 12 and 13, reflect the initial A channel findings and the readjusted A channel values after magnetron change-out.

TECHNICIAN (*Name*) TSgt JENNER, SSgt HUEHN

VIDEO MAPPER PERFORMANCE

DATE: January 1978

LOCATION: Williams AFB, AZ

ORGANIZATION: 1922 Comm. Sq.

CHECK/FRONT PANEL VOLTMETER	SPECIFICATIONS	CHECK RESULTS INITIAL	CHECK RESULTS READJUST
SECTION I. VIDEO CONVERTER			
METER POSITION #1	5.0 VDC MAXIMUM	Sat	
METER POSITION #2	5.0 VDC MAXIMUM	Sat	
METER POSITION #3	5.0 VDC MAXIMUM	Sat	
METER POSITION #4	5.0 VDC MAXIMUM	Sat	
METER POSITION #5	5.0 VDC MAXIMUM	Sat	
SECTION II SYNCRO CONVERTER			
SYNCRO CONVERTER #1			
METER POSITION #6	+5.0 TO -5.0 VDC SWING	Sat	
METER POSITION #7	+5.0 TO -5.0 VDC SWING	Sat	
SYNCRO CONVERTER #2			
METER POSITION #6	+5.0 TO -5.0 VDC SWING	Sat	
METER POSITION #7	+5.0 TO -5.0 VDC SWING	Sat	
SECTION III. PRE-TRIGGER			
PRE-TRIGGER CARD #1			
METER POSITION #8	6.0 ± 1 VDC	Sat	
METER POSITION #9	-6.0 ± 1 VDC	Sat	
METER POSITION #10	3.5 ± 1.5 VDC	Sat	
PRE-TRIGGER CARD #2			
METER POSITION #8	6.0 ± 1 VDC	Sat	
METER POSITION #9	-6.0 ± 1 VDC	Sat	
METER POSITION #10	3.5 ± 1.5 VDC	Sat	
SECTION IV. HIGH VOLTAGE POWER SUPPLY			
METER POSITION #11	5.0 ± 1 VDC	Sat	
METER POSITION #11	5.0 ± 1 VDC	Sat	
SECTION V. LOW VOLTAGE POWER SUPPLY			
POWER SUPPLY #1			
METER POSITION #12	16.0 ± 1 VDC	Sat	
METER POSITION #13	-16.0 ± 1 VDC	Sat	
METER POSITION #14	5.0 ± 1 VDC	Sat	
POWER SUPPLY #2			
METER POSITION #12	16.0 ± 1 VDC	Sat	
METER POSITION #13	-16.0 ± 1 VDC	Sat	
METER POSITION #14	5.0 ± 1 VDC	Sat	

CHECK	SPECIFICATION	MAP 1	MAP 2	MAP 3	MAP 4	MAP 5
MAP PRESENTATION	UNIFORM BRIGHTNESS AND CLARITY	Sat	Sat			
MAP ALIGNMENT	PROPER CORRELATION OF ECHOS AND MARKERS	Un Sat	Un Sat			

TECHNICIAN (Name): TSgt JENNER, SSgt HUEHN

ATCS FORM SEP 77 959

TAB: E-1-5

CONSOLIDATED SOLAR DATA RECORD

[X] SEARCH RADAR [ ] HEIGHT FINDER RADAR

1. SITE	2. LOCATION	3. POLARIZATION/BEAM	4. TYPE OF EQUIPMENT
Williams AFB	Phoenix, AZ	LP	AN/GPN-12

DATE A	PEAK TIME (Z) B	MECH TILT (Mils)/(Degrees) C	H_c (Degrees) D	REFRACTION (Degrees) E	TRUE TILT[1] (Degrees) F	TILT OR BORESIGHT ERROR[2] (Degrees) G
18 Jan 78	1511.00	7.00	6.834	0.13	6.964	0.04
19 Jan 78	0003.54	7.00	6.862	0.12	6.982	0.02
19 Jan 78	1509.96	7.00	6.721	0.13	6.851	0.15
20 Jan 78	0005.50	7.00	6.679	0.13	6.809	0.19

REMARKS 90% confidence interval computed for a sample standard deviation of 0.08 and sample size of four.

TOTAL	0.40
AVERAGE	0.10
90% CONFIDENCE VALUES	2.353
INTERVAL	±0.10
LIMITS	0.00 TO 0.20

[1] H_c plus refraction equals true tilt.
[2] Mechanical tilt minus true tilt equals tilt error or elevation boresight error.

AF FORM AUG 70 863

3

TAB: E-1-6

TITLE

ASR ANTENNA AZIMUTH ALIGNMENT CHECK

LOCATION

Williams AFB, AZ

DATE

January 1978

DATE	TIME (ZULU)	MEASURED MAGNETIC AZIMUTH	CALCULATED TRUE AZIMUTH	AZIMUTH DIFFERENCE
18 Jan	1448.5	099.0	116.8	17.8
	1454.5	100.0	117.7	17.7
	1457	100.5	118.0	17.5
	1500	101.0	118.5	17.5
	1503.5	101.5	119.0	17.5
	1508.5	102.5	119.7	17.2
	1513.5	103.0	120.5	17.5
	1519.5	104.0	121.4	17.4
	1522.5	104.5	121.8	17.3
	1530.5	106.0	123.1	17.1
	1536.5	107.0	124.1	17.1
	1540	107.25	124.6	17.35
	1544.5	107.75	125.4	17.65
	2352.5	220.5	238.3	17.8
	2356	221.0	238.8	17.8
	2358.5	221.5	239.2	17.7
19 Jan	0001	222.0	239.6	17.6
	0003.5	222.25	240.0	17.5
	0006	222.5	240.4	17.9
	0009	223.5	240.8	18.3
	0015.5	224.0	241.7	17.7
	0020.5	225.0	242.5	17.5
	0026.5	225.5	243.3	17.8
	1450	099.5	116.8	17.3
	1452	100.0	117.1	17.1
	1456	100.5	117.7	17.2
	1500	101.0	118.3	17.3
	1504	101.5	118.9	17.4
	1508	102.0	119.4	17.4
	1513	102.5	120.2	17.7
	1519	103.0	121.1	18.1
	1523	103.5	121.7	18.2
	1528	104.5	122.5	18.0
	2353	220.5	238.5	18.0
20 Jan	0000	221.5	239.6	18.1
	0006.5	222.5	240.6	18.1
	0010.5	223.0	241.1	18.1
	0013.5	223.5	241.6	18.1
	0022	225.0	242.8	17.8
			Average Difference:	17.7

REMARKS

TITLE

ASR ANTENNA AZIMUTH ALIGNMENT CHECK

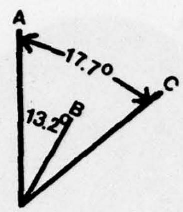
LOCATION

Williams AFB, AZ

DATE

January 1978

ASR antenna azimuth ring oriented 17.7° East of True North. Magnetic Declination 13.2° East. Error should be corrected by rotating the ASR antenna azimuth ring 4.5° CCW.



A True North

B Magnetic North

C Antenna Azimuth Ring North

REMARKS

TITLE

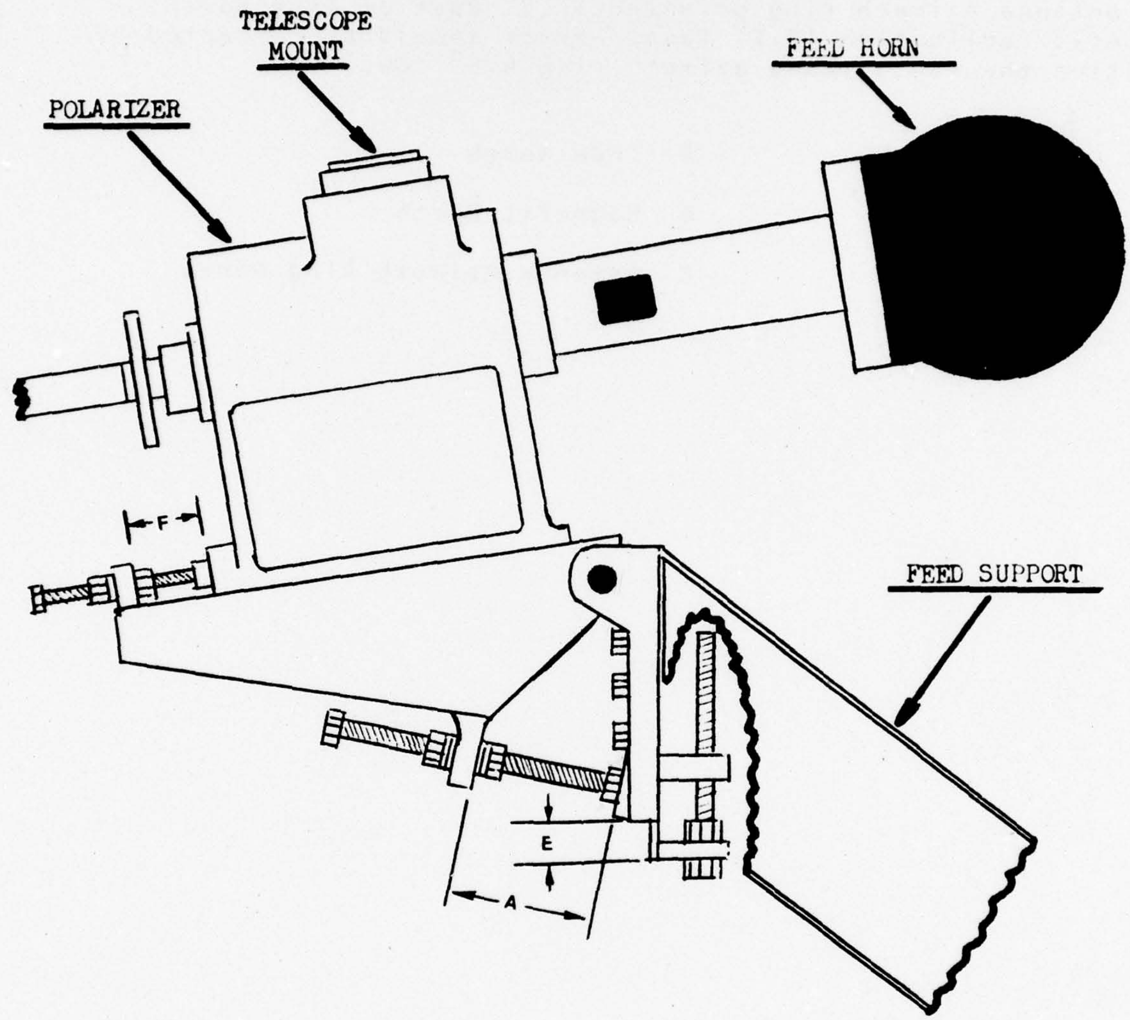
ASR ANTENNA FEEDHORN ALIGNMENT

LOCATION

Williams AFB, AZ

DATE

January 1978



ADJUSTMENT POINT	AS FOUND	FACTORY SPEC	ADJUSTED TO
A ANGLE	7 1/32"		N/A
E ELEVATION	4 15/16"		N/A
F FOCUS	2 1/16"		N/A

REMARKS

Factory specifications are not available

ATCRBS INITIAL PERFORMANCE CHECKLIST

LOCATION: Williams AFB, AZ	DATE: January 1978
ORGANIZATION: 1922 Comm Sq	TYPE ATCRBS/SERIAL NUMBER AN/TPX-42 / SN: AN/TPX-42, SN: 073

SECTION I — ANTENNA SUBSYSTEM

TYPE ANTENNAS: AT-309 Directional Antenna
AT-914 Omnidirectional Antenna

GROUND ELEVATION: 1369.6 Ft MSL	HEIGHT TO FOCAL POINT: 29.6 Ft AGL

CHECK	SPECIFICATIONS		CHECK RESULTS	
			INITIAL	READJUSTED
1. ANTENNA TILT			-1° 35'	
2. ANTENNA ORIENTATION	BEACON VIDEO COINCIDENT WITH ASR VIDEO.		Sat	
3. ANTENNA VSWR	1.5:1 MAXIMUM	OMNI	1.3:1	
		DIRECTIONAL	1.4:1	
4. ROTATION SPEED *(RPM)*			13 RPM	
5. TRANSMISSION LINE LOSS *			2.0 dB	

SECTION II — TRANSMITTER SUBSYSTEM

CHECK	SPECIFICATIONS	IR-1		IR-2	
		P-1/3	P-2	P-1/3	P-2
1. PULSE WIDTH	0.80 ± 0.1 *usec*	0.8	0.8	0.8	0.8
2. PRF	380 PPS *Maximum*	301		301	
3. *Tx* FREQ.	1030 ± 0.2 *MHz*	1030		1030	
4. TIME BETWEEN P-1 & P-3					
A. MODE 1	3.0 ± 0.1 *usec*	3.0		3.0	
B. MODE 2	5.0 ± 0.1 *usec*	5.0		5.0	
C. MODE 3/A	8.0 ± 0.1 *usec*	8.0		8.0	
D. MODE C	21.0 ± 0.1 *usec*	21.0		21.0	
5. POWER OUTPUT		INIT	ADJ	INIT	ADJ
A. P-1	LOW POWER MODE 300 WATTS NOMINAL AT J-5, OX-16.	50	200	50	200
B. P-2	LOW POWER MODE 300 WATTS NOMINAL AT J-4, OX-16.	56	225	56	225
C. P-3	LOW POWER MODE 300 WATTS NOMINAL AT J-5, OX-16.	50	200	50	200

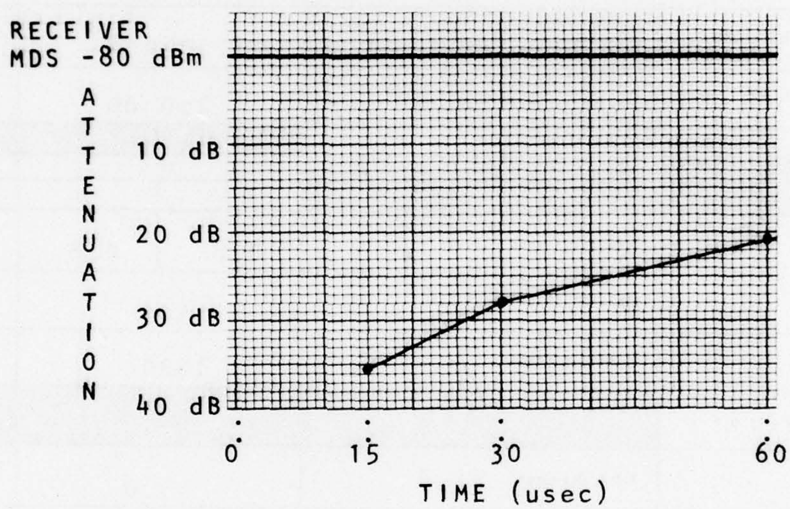
SECTION III — RECEIVER SUBSYSTEM

CHECK	SPECIFICATIONS	IR-1		IR-2	
1. RECEIVER FREQUENCY	1090 ± 0.3 *MHz*	1090		1090	
2. RECEIVER SENSITIVITY	-86 *dBm Minimum*, TP-1 VIDEO PROCESSOR CARD	-86		-86	
3. RECEIVER GAIN	2.0 ± 0.2 VDC, TP-1, VIDEO LOGIC ONE *(VL-1)*.	2.0		2.0	
4. RECEIVER SENSITIVITY	-80 *dBm*, TP-3, VIDEO PROCESSOR CARD, *(VPC)*.	-80		-80	

SECTION III. Continued on next page Nominal

SECTION III. RECEIVER SUBSYSTEM		CHECK RESULTS			
CHECK	SPECIFICATIONS	IR-1		IR-2	
		INIT	ADJ	INIT	ADJ
5. MINIMUM GTC VOLTAGE	-1.5 VDC, TP-1, *(VL-1)*.	-1.0	-2.0	-1.0	-2.0
6. GTC DELAY	10 usec *Maximum*, TP-4, VIDEO LOGIC TWO, *(VL-2)*.	12	9	12	9
7. RECEIVER GATE	2530 *usec*, TP-3, *(VL-1)*.	2400	2530	2400	2530
8. VIDEO LEVEL	5v *Max*, WITH NOISE CLIPPED AT Ø VDC, TP-3, *(VPC)*.	Sat		Sat	
9. GTC ATTEN	OPTIMIZED, BASED UPON SITE REQUIREMENTS, UTILIZING A NOMINAL 6 *dB* PER OCTAVE CURVE.				
A. 15 usec		50.0	35.5	50.0	NOTE 1
B. 30 usec		32.0	28.0	32.0	
C. 60 usec		22.0	21.0	22.0	

10. GTC WAVESHAPE



SECTION IV.	VIDEO SIGNAL PROCESSOR	INIT	ADJ
1. WINDOW SIZE	AS DETERMINED BY LOCAL OPERATING REQUIREMENTS	12	
2. WINDOW LEAD EDGE		2	
3. WINDOW TRAIL EDGE		1	
4. CONFIDENCE COUNT		4	
5. P-MODE / ALL-MODE SWITCH POSITION		ALL	
6. Δ SWITCH POSITION		±2	
7. AZIMUTH OFFSET COUNT		25	
8. PRF SWITCH POSITION		<380	
9. PROPER OPERATION OF ALL VSP FUNCTIONS.		Sat	

SECTION V. VIDEO SIGNAL PROCESSOR					
CHECK	SPECIFICATIONS	ASR-1	ASR-2	ASR-3	MAINT
1. ALTITUDE READOUT	MODE READOUT CORRESPONDS TO AIRCRAFT ALTITUDE, + 50 FEET.	Sat	Sat	Sat	Sat
2. IDENT FEATURE	INDICATOR DISPLAYS SHRINKING CIRCLES.	Sat	Sat	Sat	Sat
3. EMERGENCY CODE					
A. AURAL ALARM	AUDIBLE TONE AT INDICATOR.	Sat	Sat	Sat	Sat
B. VISUAL ALARM	IND DISPLAYS FLASHING SYMBOL.	Sat	Sat	Sat	Sat
4. LOST COMM CODE					
A. AURAL ALARM	AUDIBLE TONE AT INDICATOR.	Sat	Sat	Sat	Sat
B. VISUAL ALARM	IND DISPLAYS FLASHING SYMBOL.	Sat	Sat	Sat	Sat
5. HIJACK CODE					
A. AURAL ALARM	AUDIBLE TONE AT INDICATOR.	Sat	Sat	Sat	Sat
B. VISUAL ALARM	IND DISPLAYS FLASHING SYMBOL.	Sat	Sat	Sat	Sat
6. ALTITUDE FILTER	AS SELECTED BY A-BOX CONTROLS	Sat	Sat	Sat	Sat
7. FORMAT VIDEO	LEGIBILITY REMAINS CONSTANT FROM MIN TO MAX SETTING.	Sat	Sat	Sat	Sat
8. TARGET SYMBOL	SATISFACTORY TARGET INTENSITY COINCIDENT WITH RADAR VIDEO.	Sat	Sat	Sat	Sat
9. TARGET TRAIL TRAIL	TARGET SYMBOL (X OR 0) WITH A MAX OF THREE TRAIL DOTS.	Sat	Sat	Sat	Sat
10. DISCREET CODES	COMPLETE ISOLATION OF SELECTED CODES.	Sat	Sat	Sat	Sat
11. BRACKET VIDEO	COINCIDENT WITH RADAR VIDEO.	Sat	Sat	Sat	Sat
12. FORMAT POSITION	FORMAT COINCIDES WITH N-S-E-W SWITCH POSITION ON A-BOX	Sat	Sat	Sat	Sat

* The three cable types normally utilized in this installation, and their respective line losses are: RG-142, 50 Ohm, 12 dB per 100 ft. RG-255, 50 Ohm, 3 dB per 100 ft. RG-333, 50 Ohm, 3 dB per 100 ft.

Transmission line loss measured from J5 on the OX-16 to the antenna.

REMARKS:

NOTE 1: IR-2 GTC curve was not adjusted by the evaluation team. Local maintenance personnel were advised to adjust IR-2 GTC curve equal to IR-1.

NOTE 2: Cable loss through the OX-16 cabinet, from J-4 on the back of the IR unit to J-5 on the top of the cabinet, was 3.0 dB for IR-1 and 2.5 dB for IR-2.

TECHNICIAN: TSgt Campos-Lopez, SSgt Innis, SSgt Nowak

ASR AC POWER

EQUIPMENT/SERIAL NUMBER: AN/GPN 12 SN 39

LOCATION: Williams AFB, AZ

DATE: January 1978

TRANSMITTER SITE

CHECK	SPECIFICATIONS	A INITIAL	A ADJUSTED	B INITIAL	B ADJUSTED
LINE VOLTAGE					
"A" PHASE	105 TO 130 VAC	109			
"B" PHASE	105 TO 130 VAC	113			
"C" PHASE	105 TO 130 VAC	107			
REGULATOR OUTPUT					
"A" PHASE	120 VAC	118	120	Note 1	
"B" PHASE	120 VAC	118	120		
"C" PHASE	120 VAC	118	120		
GENERATOR	MANUFACTURER: Federal Electric	TYPE: MB-19		SERIAL NUMBER: FA253B73	
	CAPACITY: 60 KW	FREQUENCY: 60 HZ			
AUTOMATIC CHANGEOVER	MANUFACTURER: Essex	TYPE: automatic		160	
REMOTE SITE					
LINE VOLTAGE					
"A" PHASE	105 TO 130 VAC	125			
"B" PHASE	105 TO 130 VAC	126			
"C" PHASE	105 TO 130 VAC	125			
REGULATOR OUTPUT					
"A" PHASE	120 VAC	Note 2			
"B" PHASE	120 VAC				
"C" PHASE	120 VAC				
GENERATOR	MANUFACTURER: Federal Electric	TYPE: MB-15		SERIAL NUMBER: 66	
	CAPACITY: 150 KW	FREQUENCY: 60 Hz			
AUTOMATIC CHANGEOVER	MANUFACTURER: Essex	TYPE: automatic			

REMARKS:

Note 1: System voltage regulator was by-passed for the flight phase. Unregulated commercial power was adjusted to 120 volts with the variactor.

Note 2: The Williams AFB GPN 12 is not equiped with voltage regulators at the remote indicator site.

TECHNICIAN (Name): SSgt Huehn

PREFLIGHT AND POST FLIGHT EQUIPMENT LOG

LOCATION	ORGANIZATION	TECHNICIANS
Williams AFB, AZ	1922 Comm. Sq.	SSgt Huehn

DATE	POWER		NORMAL RECEIVER SENSITIVITY		MTI RECEIVER SENSITIVITY	
	PREFLIGHT	POST FLIGHT	PREFLIGHT	POST FLIGHT	PREFLIGHT	POST FLIGHT
ASR	Specs 55.5 dbm Min		Specs -108.0 dbm Min		Specs -106.0 dbm Min	
23 Jan 78	55.0	55.0	-109.0	-109.0	-108.0	-108.0
24 Jan 78	55.0	55.0	-109.0	-109.0	-108.0	-108.0
24 Jan 78	55.0	55.0	-109.0	-108.0	-108.0	-107.0
Normal log receiver sens.			Specs -106.0 dbm Min			
23 Jan 78	-108.0	-108.0				
24 Jan 78	-108.0	-108.0				
24 Jan 78	-108.0	-108.0				
MTI log receiver sensitivity			Specs -104.0 dbm Min		Specs dbm Min	
23 Jan 78	-105.0	-105.0				
24 Jan 78	-105.0	-105.0				
24 Jan 78	-105.0	-105.0				

REMARKS:

Lower power readings as listed were obtained with comparator in operation. Slightly higher specification power reading of 55.5 dBm is referenced to an operation with comparator out.

PREFLIGHT AND POST FLIGHT EQUIPMENT LOG

LOCATION	ORGANIZATION	TECHNICIANS
Williams AFB, AZ	1922 Comm Sq	SSgt NOWAK, SSgt INNIS

	POWER		NORMAL RECEIVER SENSITIVITY		MTI RECEIVER SENSITIVITY	
DATE	PREFLIGHT	POST FLIGHT	PREFLIGHT	POST FLIGHT	PREFLIGHT	POST FLIGHT
ASR	Specs	dbm Min	Specs	dbm Min	Specs	dbm Min
IFF/SIF	Specs 300 Watts Max		Specs * -80	dbm Min		
23 Jan 78	75	75	-80	-80		
23 Jan 78	125	125	-80	-80		
23 Jan 78	200	200	-80	-80		
24 Jan 78	200	200	-80	-80		
24 Jan 78	200	200	-80	-80		
PAR	Specs	dbm Min	Specs	dbm Min	Specs	dbm Min

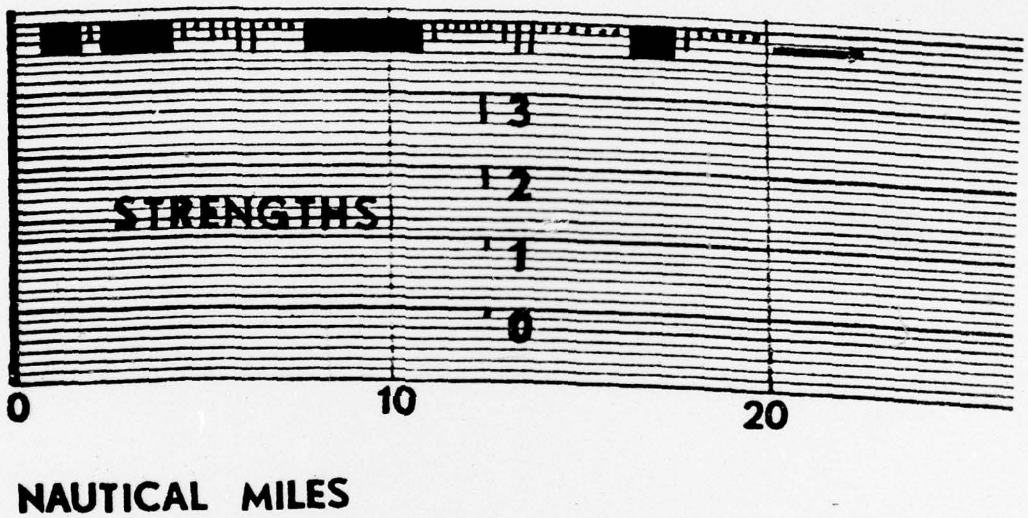
REMARKS:

* Receiver sensitivity was measured at TP3 of the Video Processor Card.

TITLE:

INTERPRETATION OF TRACKING COMPUTATIONS AND 4/3 EARTH CURVATURE GRAPH

Reference AFCS Forms 918 and 916A. Fine grain data presents target strength information in a bar graph format. The figure is an example of a fine grain data track. Target strengths are recorded IAW AFM 55-8. Three or more consecutive misses (strength one targets are counted as misses) constitute a radar hole. The number of scans per a given 5 NM distance will vary as a function of aircraft speed. Each scan of the antenna is presented as a vertical line one, two, or three units high, depending upon the scan signal strength. If the scan signal strength is zero, a dot is depicted. Tracks that are blocked consist of three or more consecutive "three" value scans. Arrows indicate aircraft direction.



DEFINITIONS:

a. BLIP: Refers to the return signal reflected from the aircraft.

b. SCAN: One complete revolution of the antenna.

c. BLIP SCAN RATIO (BSR): Total number of strength 3 and 2 blips divided by the total number of scans.

d. AVERAGE TARGET STRENGTH (ATS):

$$ATS = \frac{(3 \times a) + (2 \times b) + (1 \times c)}{\text{Total Scans}}$$

where a = Total number of strength three targets
b = Total number of strength two targets
c = Total number of strength one targets

e. MAXIMUM OUTER RANGE: The center of the last 10 scans that contain 5 usable returns, i.e. a 50% BSR.

REMARKS

DETECTION/TRACKING DATA

LEGEND: See reverse side.

PAGE 2 OF 3 PAGES

1. LOCATION	2. TYPE RADAR	3. MTI GATE	4. TYPE AIRCRAFT	5. MONTH AND YEAR
Williams AFB, AZ	AN/GPN-12 AN/TPX-42	35 NM	C-140	January 1978

TRACK NO.	DATE TIME ZULU	ALT ABOVE AFLD	AVG GROUND SPEED	ASPECT	MECH TILT	POLARIZATION	VIDEO PROC	SELECTABLE FEATURES	DETECTION RANGE (NM)		REF RANGE NM	DIF FROM REFERENCE		OUTER RNG AZIMUTH	TRACKING								ATCRBS		NOTES
															WITHIN MTI		OUTSIDE MTI		OVERALL			QUALITY			
									INNER	OUTER		NM	dB		ATS	BSR %	ATS	BSR %	ATS	BSR %	TOTAL SCANS		BSR %	OUTER RANGE	
TILT DETERMINATION																									
1	23/2105	5000	235	A	4.00	CP	F	1,2,6	4	49.0	44.0	+5	+1.9	230	2.38	76	1.23	35	2.01	63	135	C	83	55	1,5
2	23/2131	5000	278	F	4.00	CP	F	1,2,6	2	48.0	44.0	+4	+1.5	230	2.64	86	1.74	53	2.37	77	115	C	79	53	1,5
3	24/1822	5000	268	A	4.00	CP	F	1,2,6	2	36.0	44.0	-8	-3.5	230	2.82	96	2.50	100	2.81	96	94	B	75	60	4
4	24/1833	5000	246	F	4.00	CP	F	1,2,6	19	48.0	44.0	+4	+1.5	230	1.86	61	1.03	33	1.49	48	91	C	78	60	4,6
5	23/2214	5000	214	A	3.75	CP	F	1,2,6	2	51.0	46.5	+4.5	+1.6	230	2.54	82	0.94	31	1.98	64	139	C	NO	DATA	
6	23/2235	5000	248	A	3.75	CP	F	1,2,6	16	49.0	46.5	+2.5	+0.9	230	2.52	85	1.14	36	1.95	65	102	C	NO	DATA	6
7	23/2247	5000	270	F	3.75	CP	F	1,2,6	20	49.0	46.5	±2.5	+0.9	230	2.46	83	1.40	40	1.94	62	81	C	81	56	2,5
8	23/2306	5000	235	A	3.25	CP	F	1,2,6	3	51.0	50.0	+1	+0.4	230	2.56	85	1.28	38	2.14	70	143	C	70	50	3,5
9	23/2319	5000	293	F	3.25	CP	F	1,2,6	10	50.0	50.0	0	0.0	230	2.88	99	2.23	74	2.63	89	110	B	73	54	3,5,6
10	23/2338	5000	254	A	3.25	CP	F	1,2,6	5	50.0	50.0	0	0.0	230	2.65	87	1.39	45	2.23	73	133	C	62	60	3
11	23/2347	5000	300	F	3.25	CP	F	1,2,6	15	49.0	50.0	-1	-0.4	230	2.53	86	2.06	63	2.32	76	78	C	67	60	3,6
VERTICAL PROFILE																									
12	24/1613	1000	213	A	3.75	CP	F	1,2,6	0	23.0	37.5	-14.5	-8.5	230	2.51	81	----	---	2.51	81	68	D	97	40	4,5
13	24/1620	1000	300	F	3.75	CP	F	1,2,6	15	27.0	37.5	-10.5	-5.4	230	2.18	75	----	---	2.18	75	40	D	98	40	4,5,6
14	24/1630	3000	263	A	3.75	CP	F	1,2,6	15	43.0	42.5	+0.5	+0.2	230	2.21	69	1.12	35	1.87	58	84	C	93	50	4,5,6
15	24/1645	3000	240	F	3.75	CP	F	1,2,6	0	50.0	42.5	+7.5	+2.8	230	2.75	91	1.06	26	2.21	70	149	C	94	52	4,5
16	24/1701	5000	275	A	3.75	CP	F	1,2,6	1	38.0	46.5	-8.5	-3.5	230	2.48	77	1.57	57	2.42	75	105	C	70	55	4,5
17	24/1723	10000	300	A	3.75	CP	F	1,2,6	20	48.0	53.5	-5.5	-1.9	230	2.84	97	1.32	35	2.11	68	71	C	71	60	4,6
18	24/1736	10000	---	F	3.75	CP	F	1,2,6	2	47.5	53.5	-6	-2.1	230	2.13	69	1.97	68	2.10	69	154	C	83	60	4
19	24/1752	20000	336	A	3.75	CP	F	1,2,6	2	50.0	60.0	-10	-3.2	230	2.40	81	1.23	33	1.95	62	77	C	NO	DATA	4
20	24/1803	20000	336	F	3.75	CP	F	1,2,6	5	58.0	60.0	-2	-0.6	230	2.30	80	1.81	60	2.10	72	114	C	89	60	4

AFCS FORM AUG 74 918 PREVIOUS EDITIONS ARE OBSOLETE.

DETECTION/TRACKING DATA				LEGEND: See reverse side.	PAGE 3 OF 3 PAGES
1. LOCATION Williams AFB, AZ	2. TYPE RADAR AN/GPN-12 AN/TPX-42	3. MTI GATE 35 NM or as noted	4. TYPE AIRCRAFT C-140		5. MONTH AND YEAR January 1978

TRACK NO.	DATE TIME ZULU	ALT ABOVE AFLD	AVG GROUND SPEED	ASPECT	MECH TILT	POLARIZATION	VIDEO PROC	SELECTIBLE FEATURES	DETECTION RANGE (NM) INNER	DETECTION RANGE (NM) OUTER	REF RANGE NM	DIF FROM REFERENCE NM	DIF FROM REFERENCE dB	OUTER RNG AZIMUTH	TRACKING WITHIN MTI ATS	TRACKING WITHIN MTI BSR %	TRACKING OUTSIDE MTI ATS	TRACKING OUTSIDE MTI BSR %	TRACKING OVERALL ATS	TRACKING OVERALL BSR %	TRACKING OVERALL TOTAL SCANS	QUALITY	ATCRBS BSR %	ATCRBS OUTER RANGE	NOTES
FEATURE COMPARISON																									
21	24/2117	5,000	249	A	3.75	LP	F	1,2,6	2	38.0	46.5	-8.5	-3.5	230	2.74	92	2.46	85	2.71	91	99	B	79	60	4,7,12
22	24/2125	5,000	257	F	3.75	LP	F	1,2,6	30	49.0	46.5	+2.5	+0.9	230	2.07	60	2.14	69	2.12	67	57	B	81	60	4,6,7,12
23	24/2135	5,000	250	A	3.75	LP	F	1,2,6	30	47.5	46.5	1.0	+0.4	230	1.71	57	1.36	41	1.45	45	53	C	71	60	4,6,7,12
24	24/2143	5,000	250	F	3.75	LP	F	1,2,0	30	47.5	46.5	+1.0	+0.4	230	1.81	69	1.37	42	1.50	50	54	C	73	60	4,6,7,12
25	24/2152	5,000	257	A	3.75	LP	E	1,2,6	30	60.0	46.5	+13.5	+4.4	230	2.75	92	1.87	58	2.00	63	79	C	75	60	4,6,8,12
26	24/2202	5,000	267	F	3.75	LP	E	1,2,6	30	58.0	46.5	+11.5	+3.8	230	1.73	53	2.19	74	2.11	71	85	C	77	60	4,6,8,12
27	24/2213	5,000	263	A	3.75	LP	F	1,2,6,7	30	41.0	42.5	-1.5	-0.6	230	2.07	76	----	--	2.07	76	29	B	65	--	4,6,9,12
28	24/2221	5,000	260	F	3.75	LP	F	1,2,6,7	30	46.0	42.5	+3.5	+1.4	230	1.98	66	----	--	1.98	66	50	B	80	--	4,6,9,12
29	24/2229	5,000	230	A	3.75	LP	E	1,2,6,7	30	49.0	42.5	+6.5	+2.5	230	2.35	78	----	--	2.35	78	54	A	--	--	6
30	24/2242	5,000	260	F	3.75	LP	E	1,2,7	1	51.0	42.5	+8.5	+3.2	230	2.61	87	----	--	2.61	87	150	C	74	--	4,6,9,12
31	24/2256	5,000	262	A	3.75	CP	F	1,2,6,4	2	39.0	42.5	-3.5	-1.5	230	----	---	2.55	88	2.55	88	98	B	62	--	4,6,8,12
32	24/2302	5,000	264	F	3.75	CP	F	1,2,6,4	30	39.0	42.5	-3.5	-1.5	230	----	---	2.27	77	2.27	77	30	B	77	--	4,6,10,11
33	24/2308	5,000	300	A	3.75	CP	F	1, 6,4,7	30	32.0	39.0	-7.0	-3.4	230	2.50	92	----	--	2.50	92	12	A	58	--	4,6,10,11
34	24/2323	5,000	250	F	3.75	CP	F	1,2,6,4,7	1	34.0	39.0	-5.0	-2.4	230	2.92	99	-----	--	2.92	99	106	B	92	55	4,10,11

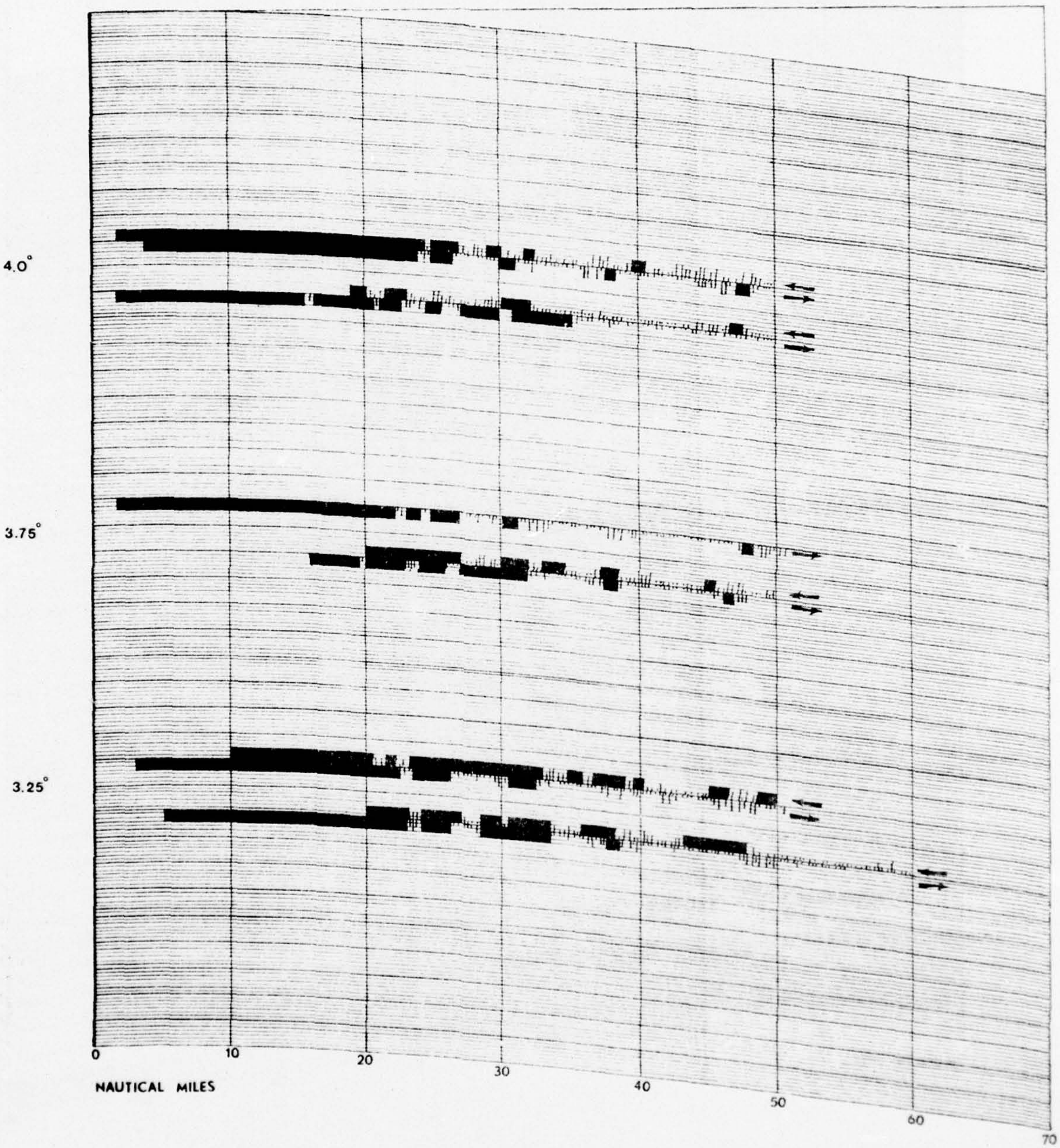
AFCS FORM AUG 74 918 PREVIOUS EDITIONS ARE OBSOLETE.

TAB: F-1-4

TITLE

TILT DETERMINATION COVERAGE CHART

LOCATION	DATE
Williams AFB, AZ	January 1978



REMARKS

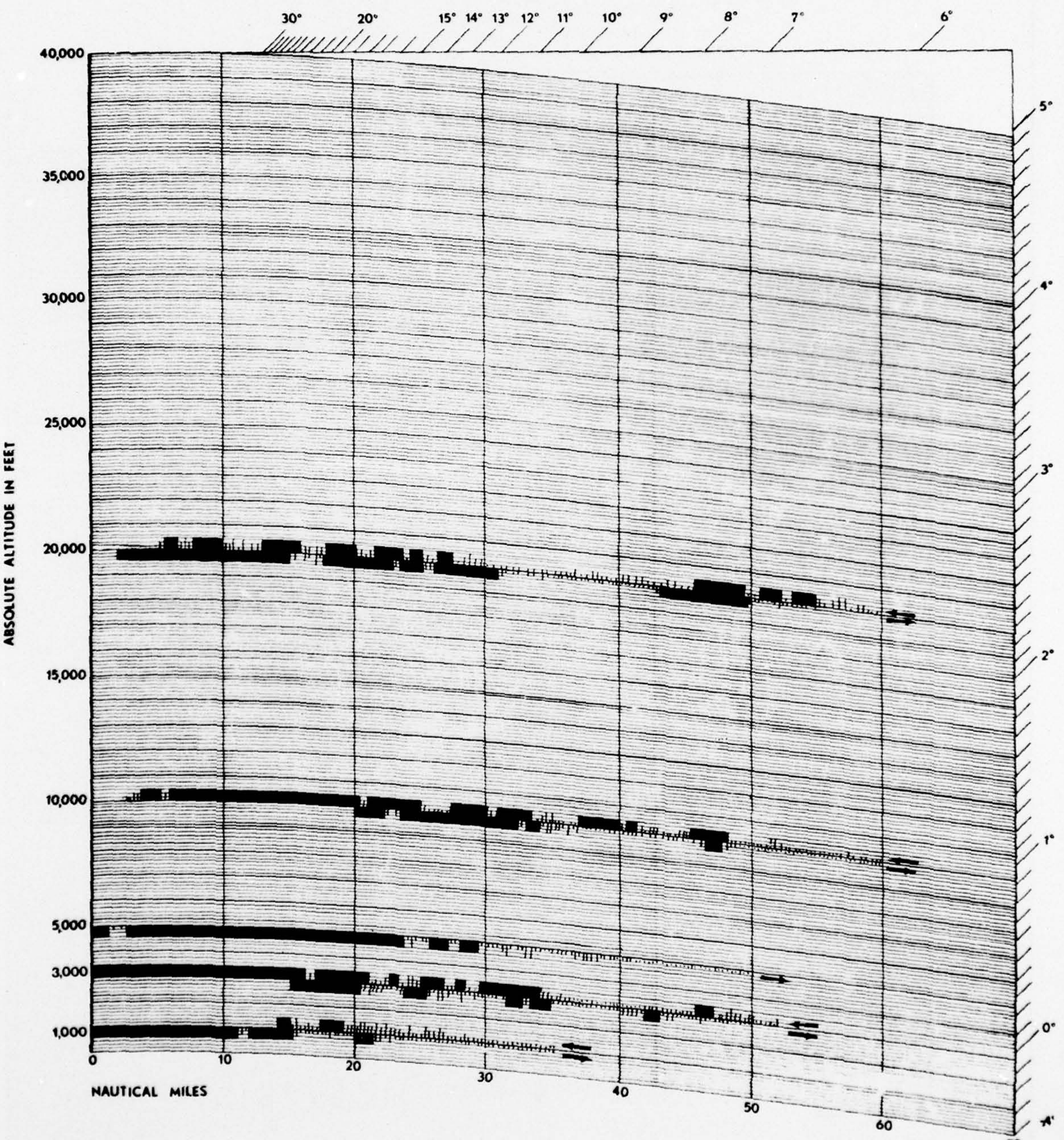
4/3 Earth Curvature Profile. Flown on the 230° radial at 6400 feet MSL. Ground elevation at site 1369.6 feet MSL.

TITLE

VERTICAL PROFILE COVERAGE CHART

LOCATION: Williams AFB, AZ

DATE: January 1978



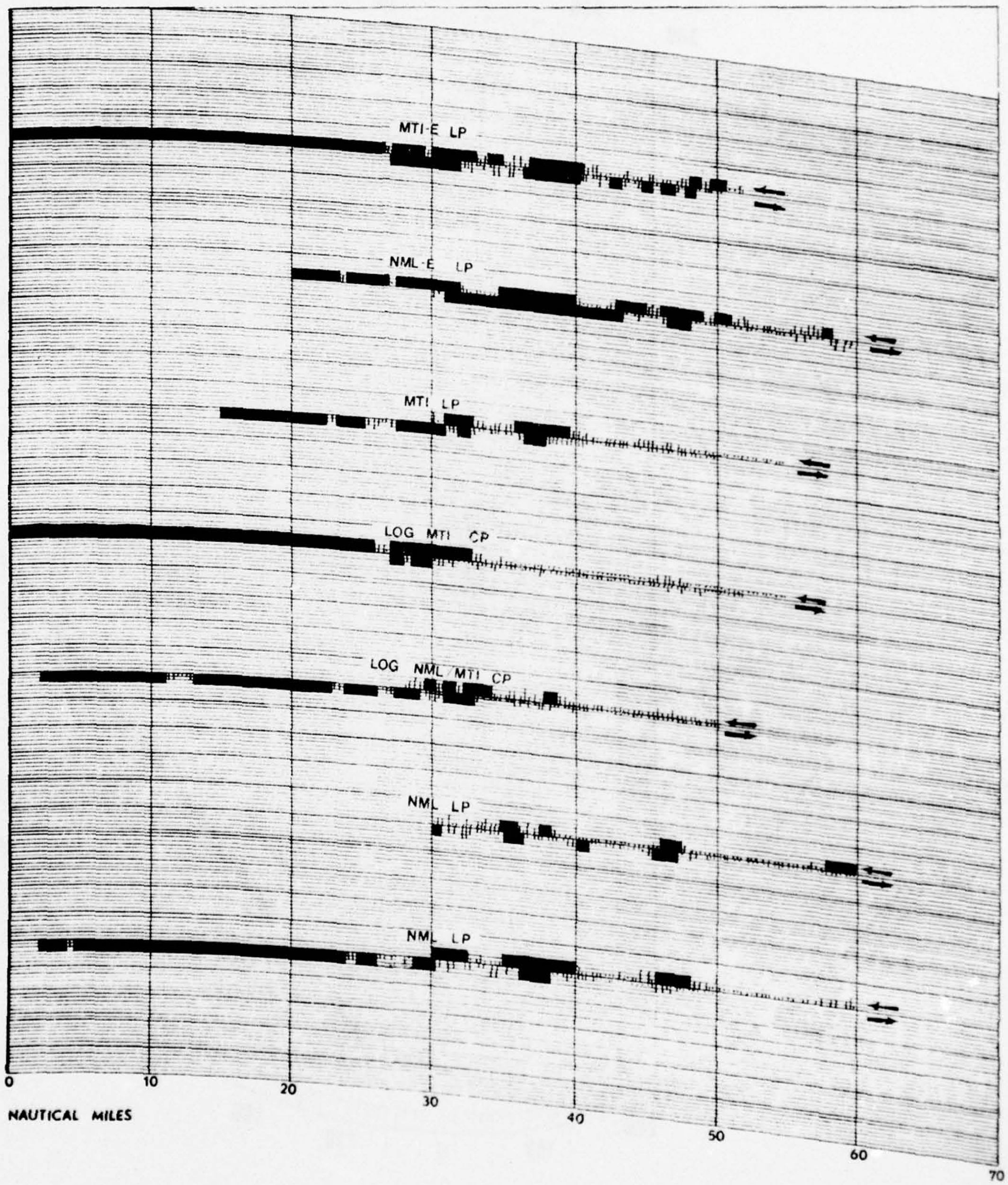
REMARKS: 4/3 Earth Curvature Profile. Flown on the 230^{o} radial. Ground elevation at site 1369.6 feet MSL.

TITLE:

FEATURE COMPARISON COVERAGE CHART

LOCATION: Williams AFB, AZ

DATE: January 1978



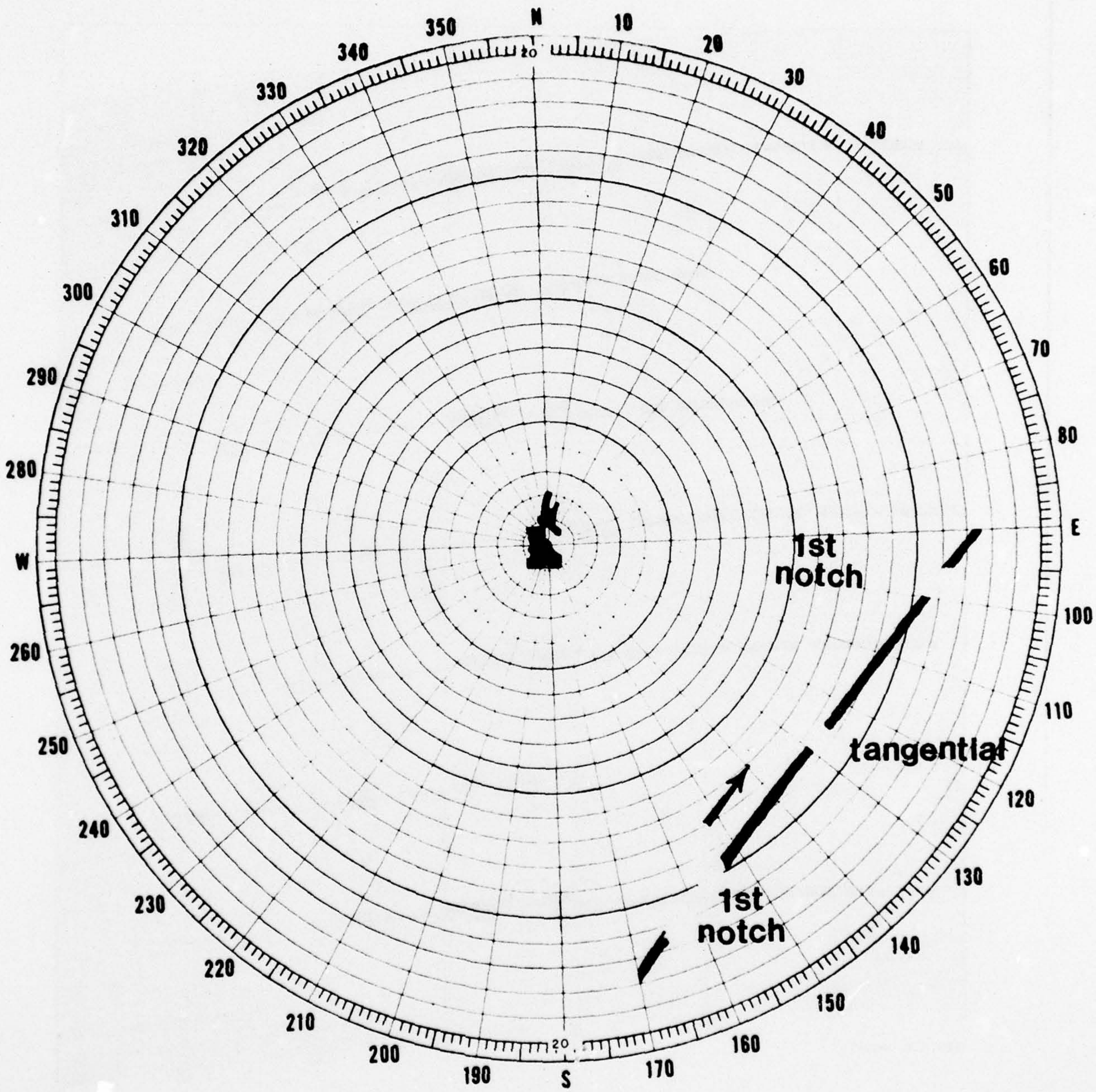
REMARKS: 4/3 Earth Curvature Profile. Flown on the 230^{0} radial at 6400 feet MSL. Ground elevation at site 1369.6 feet MSL.

TITLE:

BLIND SPEED TEST (STAGGER PRF OFF)

LOCATION: Williams AFB, AZ

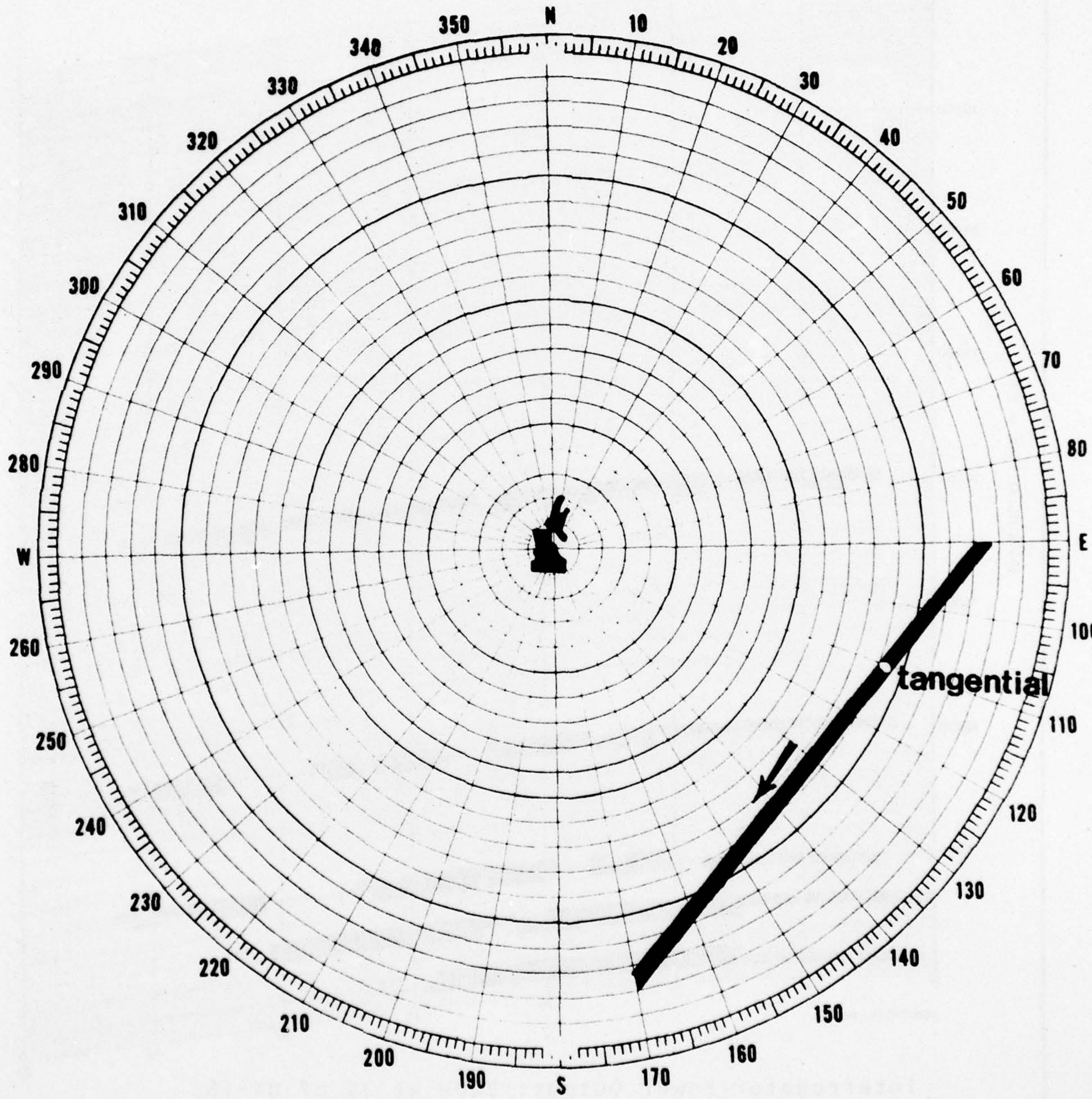
DATE: January 1978



REMARKS: Aircraft ground speed 250 Kts, MTI gated to 52 NM. Oriented to Magnetic North. Magnetic variation 13.2 degrees East

TITLE:
BLIND SPEED TEST (STAGGER PRF ON)

LOCATION	DATE
Williams AFB, AZ	January 1978



NOTE: Because of high winds aloft, aircraft was actually tangential on the 110° radial.

REMARKS
Aircraft ground speed 250 Kts, MTI gated to 52 NM. Oriented to Magnetic North. Magnetic variation 13.2 decrees East.

TITLE

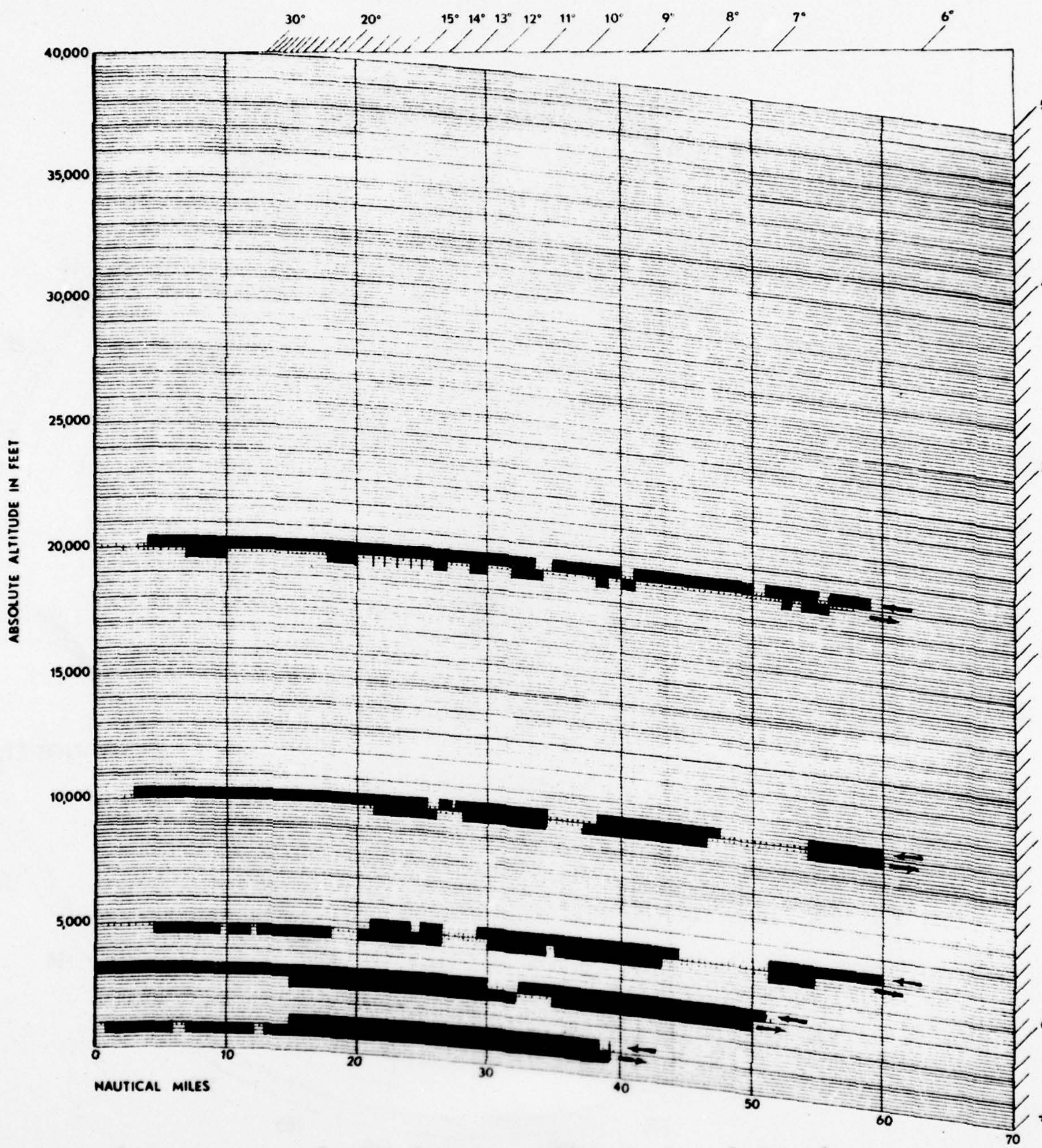
VERTICAL PROFILE COVERAGE CHART (AN/TPX-42)

LOCATION

Williams AFB, AZ

DATE

January 1978



Interrogator Power Output: 200W at J5 of OX-16.
Transponder Power Output: Approximately 238 W at antenna.
Transponder Sensitivity: Approximately -66 dBm at antenna.

REMARKS Flown on the 230° radial.
Ground elevation at site 1369.6 feet MSL.

AFCS FORM MAY 73 906 GENERAL INFORMATION TAB:F-6

TITLE:

REFRACTIVE THEORY AND DEFINITIONS

1. The bending or refraction of electromagnetic energy as it passes through the air occurs because of the structure of the troposphere. Energy propagated through a vacuum would travel in a straight line. Similarly, energy transmitted through any gas (or liquid) that is uniform in density perpendicular to the direction in which the energy is traveling, will follow a straight line path. However, due to the physical characteristics of the troposphere, the density of the troposphere decreases with increasing height. Therefore, the front of energy transmitted at low elevation angles will be subject to refractive bending. Usually, the top of the wave front will move faster than the bottom, since the density of the atmosphere decreases with height. The result is a downward bending of the transmitted energy.

2. The number that describes the relative speed of propagation in any substance is referred to as the index of refraction (n). It is defined as the ratio of the speed of propagation of electromagnetic energy in a vacuum (c) to the speed of propagation of electromagnetic energy in the medium in question (v):

$$n = \frac{c}{v}$$

Within the wavelength band from 1 cm (30 GHz) to 10 meters (30 MHz), the index of refraction does not change appreciably as the frequency changes. The typical range of values of n at sea level is from 1.000250 to 1.000450. Since these numbers are difficult to work with, a "scaled-up" quantity called refractivity (N) is used, and is defined as

$$N = (n - 1)\, 10^6$$

Thus the range of values of refractivity at sea level becomes 250 to 450 N-units.

3. As mentioned earlier, the bending of energy is caused by the change in density with height in the air. Since the speed of propagation of energy is related to the density of the air, and the refractivity (N) is related to the speed of propagation of energy (by definition), then refractivity in the troposphere is directly related to the density of the air. Therefore, the bending of electromagnetic energy may be thought of as due to the change of refractivity with height in the troposphere, or the vertical gradient of refractivity. It is important to note that it is not the value of N at a particular point that determines refraction but it is the gradient of refractivity that must be considered. The refractivity may be related to the meterorological variables of pressure (p), temperature (T), and water vapor pressure (e) by the following equation:

$$N = \frac{Ap}{T} + \frac{Be}{T^2}$$

where A and B are constants. The normal rapid decrease of p and e with height in the troposphere leads to a decrease of N with height. Temperature usually decreases slowly with height, and this has an opposite effect on the change of N. In the so-called "standard" atmosphere, the result is that N will decrease by about 12 N-units per 1000 feet of altitude through the lower levels of the troposphere, and 6 N-units per 1000 feet in the upper levels. It is this decrease of refractivity with height that leads to the "normal" downward curvature, or refraction, of electromagnetic energy.

REMARKS

TITLE:

REFRACTIVE THEORY AND DEFINITIONS

4. In the "real" troposphere all is not so simple. The temperature and water vapor pressure may vary in any manner, while atmospheric pressure will continue to decrease with height. This seemingly random variation of the meteorological terms will lead to unusual changes in refractivity with height. Refractivity may decrease more than in the "standard" troposphere, causing more pronounced bending of electromagnetic energy. On the other hand, refractivity may actually increase with height, which may result in an upward curvature of a radio/radar beam (opposite the curvature of the earth). The propagation of electromagnetic energy along a path that is different from the usual or expected path is known as "anomalous propagation" (AP). The refraction that results under various AP conditions is referred to as either subrefraction, superrefraction, or trapping (ducting). These refractive conditions, the effects on electromagnetic energy presented as a single ray, and the gradients of refractivity that may cause them are defined below:

a. Subrefraction: Ray curvature is upward. Radio/radar ranges are significantly reduced. The occurrence is quite rare. The gradient of refractivity is equal to or greater than 0 N-units/1000 feet (average "standard" value is - 12 N-units/1000 feet).

b. Normal refraction: Ray curvature is downward but not as much as the curvature of the earth. Radio/radar performance is generally undisturbed, and the occurrence is frequent. The gradient of refractivity is less than 0 N-units/100 feet and greater than - 24 N-units/100 feet.

c. Superrefraction: Ray curvature is downward, more sharply than normal, but not as much as the curvature of the earth's surface. Radio/radar ranges may be significantly extended; the occurrence is frequent. The gradient of refractivity is greater than -48 N-units/100 feet and less than or equal to -24 N-units/1000 feet.

d. Trapping: Extreme superrefraction, with downward curvature equal to or greater than the curvature of the earth's surface. Radio/radar performance is greatly disturbed, ranges are greatly extended, holes in coverage may appear; occurrence is not normally frequent. The gradient of refractivity is less than or equal to -48 N-units/1000 feet.

5. For an understanding of refractive effects on the system being evaluated, refer to AFCS Pamphlet 100-79.

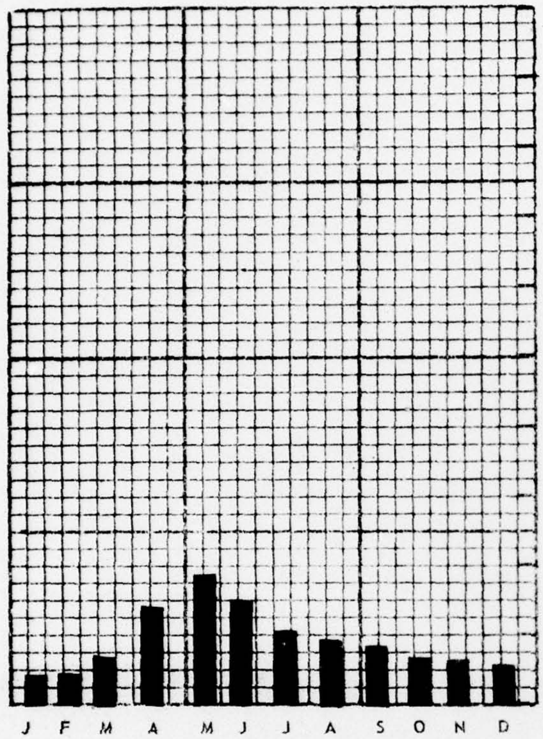
REMARKS

FREQUENCY OF REFRACTIVE CONDITIONS IN PERCENT

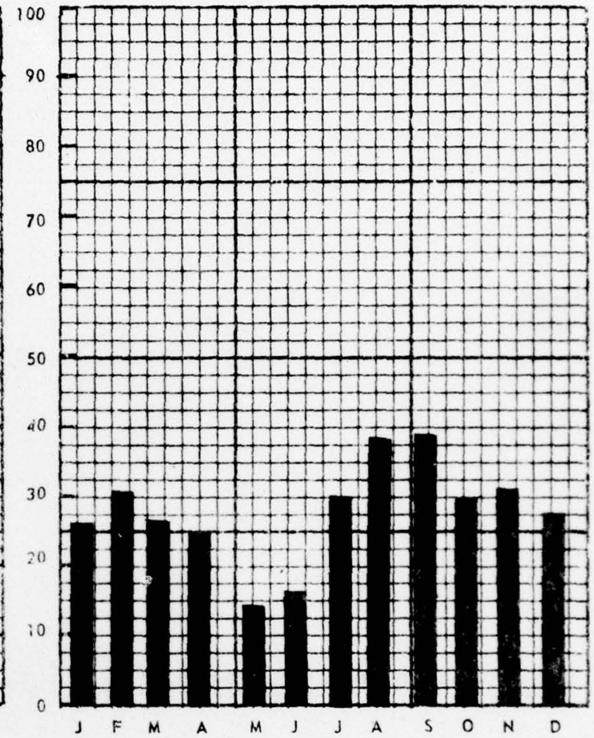
NAME OF BASE

Williams AFB, AZ

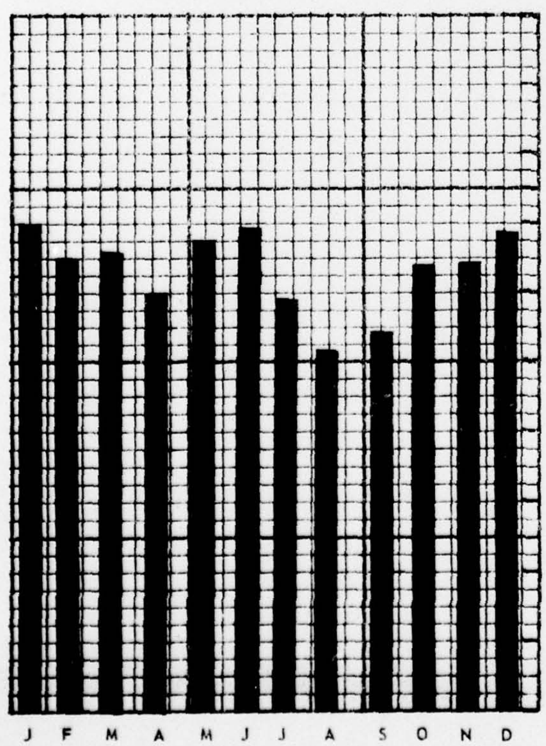
TRAPPING



SUPERREFRACTIVE



NORMAL



SUBREFRACTIVE